MYCOLOGIA

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William W. Diehl

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FUNDAMENTALS IN MYCOLOGY[1]

WILLIAM W. DIEHL

(WITH PORTRAIT)

I have worked for some 35 years ostensibly as a taxonomist of fungi but by force of circumstances concerned with almost every phase of mycological interest. I have been just a hired man in a public-service organization serving at different tasks, chiefly as prescribed by custom and the exigencies of the moment. Although these tasks have frequently seemed too little integrated, sometimes even pointless, they have all been concerned with fungi, their various aspects, activities and uses as well as their identities—usually with a broad range of human interest. Throughout I have had the viewpoint of a taxonomist and I trust I may be pardoned if my remarks here reflect this viewpoint. As a consultant I have met with embarrassing frequency interrogations as to what in mycology may be regarded as most basic or fundamental.

It may be presumptuous to address this audience with its diverse experiences, specialized interests and presumably well developed opinions on such a subject. I have no apology except that the opinions here offered were not originally my own but have been implanted from various sources and stimulated by casual discussions with others often not in agreement with me or even with each other. I refer to physical facilities that I deem fundamental or essential to continuing progress in mycology.

[1] Presidential Address, Mycological Society of America. Presented September 8, 1955, at the Society meetings in East Lansing, Michigan.

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THE LABORATORY

Most of us will agree, I believe, that the use of fungi as tools of research or as test organisms (guinea pigs, if you will) in other disciplines, although not subjectively mycology, is so integrated that the relation has become fundamental. Researches on their physiology and genetics, including their pathogenesis in plants and animals, have tended to be interrelated to researches on their morphology and their taxonomy, to which valuable knowledge has been made available also through recent utilization of fungi in industry. The taxonomic mycologist, especially, is forced by example and competition in other disciplines and by the accelerated pressure of his contacts to utilize many new techniques and modern equipment and to improve these, or he is stranded, if not engulfed, in sluggish backwaters of the rapidly moving stream of modern science and technology. Yet it is too common a complaint that taxonomic mycologists lack adequate laboratories. It is regrettable that too often, even where the best of present-day herbarium and library facilities may be available to them, the laboratory equipment is scarcely superior to that of Persoon and Fries over a century ago. This condition may be less difficult to explain than to justify. Whatever the cause of this imbalance in equipment, the effect is with us and the cure not far to seek. I believe that when mycologists will have had laboratory facilities more adequate by modern standards in other fields their rôle in further revealing the secrets of nature as well as their impact on the technological scene will be correspondingly more effective.

MYCOLOGICAL HERBARIA

The reference collection of specimens of fungi, or mycological herbarium, containing standard exsiccati and preferably types or fragments of types, was once an important adjunct of any institution concerned with mycological instruction or research and has been traditionally recognized as essential to any consideration of fungal identities. The present-day general acceptance of the International Code of Botanical Nomenclature requiring reference to types as the last word in determining application of the name of any entity or taxon gives the herbarium a status never before attained. Types and authentic specimens are now standards by which all taxa must be measured. Yet coincident with this modern acceptance of the type concept as fundamental many mycological herbaria have fallen on evil times. Most universities and many other institutions concerned with various aspects of mycological activity tend in this country to avoid maintaining any significant refer-

ence collections of specimens. Some, indeed, tolerate but scarcely utilize specimens inherited from a former day. Unless utilized and appreciated, mycological herbaria cannot be advantaged by accretions and improved practices; they deteriorate with inadequate or no maintenance and may be lost, discarded or even destroyed. Indeed this has been the fate of too many of them. The fact that but few mycologists are included in the Index Herbariorum, A–D, recently compiled by Lanjouw and Stafleu may well be due in part to an actual loss of many collections of fungi. I have for some years attempted to compile a similar record restricted to fungi and have been distressed at my inability thus far to find what has become of many critical mycological specimens.

This tendency toward depreciation of mycological assets, like that of currency today, is not limited to the U. S. A. In 1950, I visited the Botanical Institute of a certain European university now active in other botanical fields but once notable for researches on fungi and still suspected of housing mycological specimens of yesteryear. I found that the members of the botanical staff seemed in doubt whether such specimens actually existed. Fortunately one of them finally revived a vague recollection of specimens stacked in the attic and with another courteously helped me search. There, under the eaves, still safely shrouded in ancient newspapers, were thousands of specimens bearing no evidence of having been disturbed by either moth or man for the last 75 years.

It must be recognized that the mycological herbarium is not a repository for types only; it should be a collection of any specimens or microscopic preparations that have been cited in the literature, making possible later reappraisals of questionable identities. Since mutations or the intrusion of contaminants may affect some fungi in artificial culture the preservation of dried cultures and of slides as reference specimens insures a later appraisal of the original characters of a particular culture. Specimens are fundamental references also to the physiologist and plant pathologist and in certain instances can be of special moment in the evaluation of cultures used in industry.

CULTURES AND CULTURE COLLECTIONS

The culture of fungi on artificial media, and in restricted instances as parasites on living plants and animals, is now so much an accepted practice that some methods, like some media, have become standardized, even stereotyped. The plant pathologist, the medical mycologist and the physiologist, often more adequately supplied with culture equipment,

continue to lead in culture techniques. They frequently send cultures to the taxonomist in expectation of aid or service in solving taxonomic enigmas. The taxonomist, too often lacking means requisite for comparative culture studies, has sometimes thus acquired the reputation of the scriptural servant with the single buried talent. Need for permanent reference cultures in mycological researches and for stock cultures of fungi in industry became so obvious some years ago that a number of American culture collections had been projected, and some actually got under way largely with the influential backing of the bacteriologists concerned with medicine and the good will of other groups. As you are all aware most of these ventures have not survived. Even the very deserving American Type Culture Collection has encountered recurrent threats to its survival. Here again the problem is one of financial support. The survival and growth of not only one but of several comprehensive collections of pedigreed cultures of fungi would seem as fundamental to the practical applications of fungi and to mycological progress as is the maintenance of clones and pedigreed seed cultures and of pedigreed animal lines to agriculture and husbandry.

LIBRARIES AND CATALOGUES

Just as pedigreed cultures and authoritative specimens provide means for comparing the unknown with the known and furnish initials from which to build, so the well-catalogued Library enables us to utilize previous records. The larger technical libraries tend to be well managed and to have reasonably comprehensive catalogue facilities. Nevertheless, the best of these general catalogues will not enable one to trace comprehensively the records of a particular species. This was so apparent to W. J. V. Oudemans and to W. G. Farlow over half a century ago that they developed their comprehensive catalogues—only to be overwhelmed later by the growing flood of publication. Today when it is needful to seek records of a particular species one is faced with the necessity for laborious, time-consuming search through the many indices in standard technical journals and abstracts. The *Review of Applied Mycology* may best meet our needs as a recent starting point. From there on the searcher is on his own and he needs a long life-time of experience, unusual perseverance and an innate sixth or seventh sense in following out hunches. In some institutions one occasionally finds little heralded, unpublished catalogues or indices to literature concerning species or special subjects that can prove to be clear-cut, time-saving guides far preferable to dependence on casual hunches. Special catalogues and indices are necessarily expensive to make and maintain.

Regardless of the fundamental advantage in keeping these work-saving tools at hand the housing they require is too often in competition with demands for the spacious room with a single empty desk and a velvet rug.

PERSONALITIES

Effectiveness in any human activity depends ultimately on the human element. A perspective of mycological history reveals a remarkable record of achievement with primitive equipment. Acumen, selflessness, honesty and perseverance here, as in other fields of scientific endeavor, have achieved much despite handicaps, and can be expected so to continue, although less effectively in the absence of adequate tools. In the competitive era of mechanization in which we now find ourselves mycology must, nevertheless, offer satisfaction in efficient accomplishment if it is to recruit and retain in its services those individuals to whom these virtues have meaning.

CONCLUSION

Mycology cannot progress if equipped and nourished as a botanical step-child. Nor can it be submerged as a mere handmaiden in the diverse practical byways of other fields of science. It is fortunate in inheriting with its botanical outlook and traditions the wholesome expectation for an intelligible nomenclature. By recognizing taxa in terms of specimen records in support of effective descriptions and reinforced by experimental methods in field and laboratory it retains the advantages of botanical precedent and benefits by modern practices. Only by utilizing modern equipment and constantly improved techniques may the mycologist be enabled to keep abreast of developments in other sciences and to bear adequately his share of research and service in the technological era we face today.

NATIONAL FUNGUS COLLECTIONS,
U. S. DEPT. OF AGRICULTURE,
BELTSVILLE, MARYLAND

FATTY ACIDS AS CARBON SOURCES FOR THE GROWTH OF SPICARIA VIOLACEA [1]

G. T. Johnson

During the microbiological examination of various soils the writer noted that *Spicaria violacea* Abbott appeared to be isolated somewhat selectively through enrichment techniques based on the use of fatty acids in the assay medium. In view of the widespread interest in general fat metabolism and the possible role of fungi in the deterioration and rancidity of fats, the normal physiology of this organism has been investigated, with particular reference to its growth on the saturated fatty acids. The data resulting are incorporated in the present report.

Cultures of *S. violacea* isolated from soil were maintained on V-8 and Sabouraud's glucose agar. Growth studies were made in liquid culture media composed of a Czapek-Dox mineral salts solution ($NaNO_3$, 2 g; K_2HPO_4, 1 g; KCl, 0.5 g; $MgSO_4 \cdot 7H_2O$, 0.5 g; $FeSO_4 \cdot 7H_2O$, 0.01 g; water, 1000 ml) containing a single carbon source as indicated in the experiments below. The phosphate was sterilized separately and added with aseptic techniques. The magnesium ion was omitted to avoid interaction with the fatty acids when they were incorporated in the medium ($MgSO_4 \cdot 7H_2O$ was replaced by Na_2SO_4, 0.5 g for these experiments). All fatty acids (commercial preparations from Fisher, Eastman, and Nutritional Biochemicals) were converted to the potassium soap with potassium hydroxide in absolute alcohol, precipitated and washed with anhydrous ether, and dried in a vacuum desiccator. Inoculations were made with 1 ml of a heavy spore suspension (sterile distilled water) from 14-day cultures grown on Sabouraud's glucose agar into 250 ml Erlenmeyer flasks containing 65 ml of medium. Surface cultures were not agitated; submerged cultures were grown on a Brunswick rotary type shaker revolving 280 rpm. Hydrogen ion measurements were made with a Beckman Model G Glass Electrode pH meter. Growth measurements were based on dry weights of the mycelial mats, removed from the cul-

[1] This investigation was supported in part by a grant-in-aid from the American Cancer Society, upon recommendation of the Committee on Growth of the National Research Council. It includes some work done while a Research Participant, Medical Division, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee, under contract with the United States Atomic Energy Commission.

ture medium by filtration, washed with distilled water, and dried to constant weight in an oven at 45° C.

EXPERIMENTAL RESULTS

Experiments designed to investigate the general conditions required for the growth of *Spicaria violacea* are presented in TABLE I. Best growth on glucose was obtained with a substrate concentration of 5%;

TABLE I

EFFECT OF SUBSTRATE CONCENTRATION, pH, TEMPERATURE, AND AERATION ON GROWTH OF SPICARIA VIOLACEA [1]

Substrate concentration	Glucose growth	Glycerol growth	Temperature	Glucose growth	Glycerol growth
0.5	.0978	.0601	15° C.	.3433	.2339
2.5	.3770	.3358	20° C.	.4056	.2972
5.0	.4352	.4186	25° C.	.4081	.6445
10.0	.4223	.4662	30° C.	.4536	.6854
20.0	.4185	.6020	35° C.	.1914	.7163

Hydrogen Ion Concentration

Czapek-Dox Glucose			Czapek-Dox Glycerol		
Initial pH	Final pH	Growth	Initial pH	Final pH	Growth
3.22	5.52	.3386	3.08	5.61	.5088
4.29	5.59	.4564	4.72	7.91	.6687
5.51	6.78	.4421	6.00	7.23	.6946
6.51	6.63	.4592	7.48	8.12	.7138
7.54	6.58	.4536	7.93	8.78	.6854
9.02	7.92	.3659	9.01	8.89	.6662

Aeration

Czapek-Dox Glucose			Czapek-Dox Glycerol		
Time days	Surface growth	Submerged growth	Time days	Surface growth	Submerged growth
2	.0044	.0126	2	.0077	.0269
3	.0259	.0967	3	.0175	.1235
4	.0923	.3606	4	.0421	.2439
6	.2922	.4017	6	.1074	.3790
8	.3014	.6452	8	.1809	.5139
11	.5272	.6290	11	.3425	.5952
14	.5348	.6070	14	.6046	.6345
21	.6113	.5082	21	.6065	.7127
28	.6424	.4967	28	.6337	.7198

[1] Growth is measured as dry weight in grams per flask. Unless otherwise indicated: Substrate concentration, 5%; Temperature, 25° C; Initial pH, 7.2–7.4; Surface growths; Time, 14 days.

increased growth occurred with concentrations up to 20% on glycerol. This organism grew best at a neutral to slightly alkaline pH, and in general (particularly on glycerol) the medium became slightly more alkaline during growth. On glucose *S. violacea* attained maximum weight at a temperature near 30° C; on glycerol the optimum was slightly above this point. At sub-optimum temperatures (15–20° C) growth was somewhat better on glucose than on glycerol; at higher temperatures glycerol provided definitely superior yields. On glycerol better growth was obtained in submerged as opposed to surface cultures as shown by all data obtained in periods up to 28 days; on glucose this relationship held for 14 days, when considerable autolysis in submerged culture resulted in a decrease in weight. Growth was significantly greater in submerged cultures for about two weeks; however, after two weeks the weights of surface and submerged cultures tended to become more nearly the same. The organism is highly aerobic; cultures placed in N_2 atmosphere did not grow. While these data do not precisely delimit optima under all possible environmental variations, they do suffice to formulate suitable conditions under which reliable data for growth on fatty acids can be obtained.

Growth assays on saturated fatty acids of chain length from C_2 to C_{18} (except C_{15} which was not available), each taken separately as a sole carbon source, were carried out at 30° C, initial pH 7.2, as surface growths, and at a substrate concentration of 0.5 per cent (TABLE II). The survey work suggested that higher substrate concentrations might have been desirable, but considerations of solubility, possible toxicity, and economy of purified chemicals led to the selection made. At three weeks glycerol had provided the best growth of all substrates tested. The C_{18}, C_{16}, C_7, C_6, and C_5 fatty acids all provided better growth than glucose. Cultures on C_{12}, C_{11}, and C_{10} fatty acids did not grow. The barest visible trace of growth appeared on C_{13}, C_9, and C_8 substrates, so slight as to suggest this growth came solely from germination of the spores. C_2, C_3, C_4, C_{14}, and C_{17} acids also gave a definite growth response.

After six weeks some individual shifts in the relative order of "best growth" had occurred, but the general picture was much the same. The C_2–C_7 and C_{14}–C_{18} acids gave considerable growth; growth on C_8–C_{13} acids was absent or very slight.

In these experiments the medium became quite alkaline, perhaps due to the accumulation of potassium bicarbonate as the soaps were utilized. This may have affected the rate of growth, particularly when the medium approached a pH of 9.0 (*cf.* acetate data for three *vs.* six weeks time,

TABLE II

GROWTH OF SPICARIA VIOLACEA ON SATURATED FATTY ACIDS [1]

Substrate	Growth 3 weeks	Growth 6 weeks	Final pH 3 weeks	Final pH 6 weeks
Stearate	.2085	.2295	7.8	8.0
Margarate	.1275	.1395	7.6	7.7
Palmitate	.1530	.1815	7.8	7.8
Myristate	.0635	.2820	7.3	9.1
Tridecanoate	.0025	.0300	7.1	7.3
Laurate	.0000	.0000	7.1	7.2
Undecylate	.0000	.0000	7.3	7.3
Caprate	.0000	.0000	7.2	7.3
Pelargonate	.0006	.0015	7.2	7.3
Caprylate	.0009	.0185	7.4	7.9
Heptate	.2300	.3810	8.6	9.3
Caproate	.3565	.3610	8.8	9.3
Valerate	.1590	.2815	8.7	9.1
Butyrate	.1055	.2070	8.7	9.1
Propionate	.0980	.1460	8.9	9.2
Acetate	.1198	.1100	9.3	9.5
Glucose	.1420	.3185	6.6	7.7
Glycerol	.3435	.4385	7.9	8.6

[1] Czapek-Dox medium (modified) with 0.5% carbon source; Initial pH 7.2; Surface growths; Temperature 30° C. Growth is measured as dry weight in grams (5 flasks).

TABLE II). However, this interference did not occur until a considerable amount of growth had taken place. It might be pointed out that if some allowance is made for the fact that the shorter chains introduce more potassium ions for a given substrate weight, measurement of the final pH roughly correlates with dry weight as a measure of growth on the potassium soaps.

DISCUSSION

The ability to grow on fatty acids as a sole carbon source is not unique among the molds, having previously been reported for several forms, *e.g. Penicillium glaucum* (Stärkle, **1924**), *P. palitans* (Stokoe, **1928**), *Aspergillus niger* (Stärkle, **1924**; Mukherjee, **1952**), *A. fumigatus* (Stärkle, **1924**), *Leptomitus lacteus* (Schade, **1940**), *Mucor mucedo* (Stern *et al.*, **1954**), etc. So far as the writer is aware *Spicaria violacea* has not previously been associated with this nutritional characteristic. Since *S. violacea* readily utilizes both glycerol and many of the saturated fatty acids, even showing better growth on such substrates than on glucose, it seems highly adapted for growth on fats. Further, the isolation of this organism from several soils through enrichment cultures based on these substrates suggests a possible role for *S. violacea* in the degradation of lipid organic matter in such soils.

Knoop (**1905**) found that when a series of phenyl fatty acids were fed to animals, analyses of the excretion products in the urine suggested that the fatty acids lost their carbon atoms two at a time. Dakin (**1908**) identified β-keto and β-hydroxy acids as intermediates in this process. This work established the β-oxidation theory in fatty acid metabolism which stated that fatty acid oxidation proceeds through the formation of a β-keto acid, which is then oxidized at the carbonyl group to the fatty acid with two carbon atoms less, the two carbon fragment usually being identified with acetic acid. Hence the metabolism of stearic acid (C_{18}) would proceed to a C_{16} (palmitic acid) intermediate, then through successive stages to C_{14}, C_{12}, C_{10}, C_8, C_6, etc. Knoop's theory has been confirmed in general and extended as to details in recent years (see Green, **1954**) by the isolation of enzyme systems (obtained primarily from mammalian cells) which carry out the reactions concerned, although fatty acyl CoA derivatives rather than the free fatty acids have been found to be the key initial intermediates involved.

If the long chain fatty acid metabolism of *S. violacea* proceeds by β-oxidation it is difficult to understand why lauric and capric acids do not provide for growth under conditions where stearic and palmitic acids are readily utilized. It is also interesting to note that C_7, C_6, and C_5 acids provide excellent growth response. No deductions as to the mechanisms involved are justified on the basis of the physiological data now at hand. However, selective growth responses of *S. violacea* to saturated fatty acids appear to be associated with some chain length specificity. Further work is in progress to ascertain the nature of this relationship.

SUMMARY

1). *Spicaria violacea* can be grown on a mineral salts solution with fatty acids as a sole carbon source.

2). Excellent growth response to glycerol and to selected fatty acids suggests that this organism is well adapted to fatty substrates, possibly playing a role in the degradation of lipid organic matter in the soil.

3). C_{18}, C_{16}, C_7, C_6, and C_5 fatty acids provided excellent growth response; C_2, C_3, C_4, C_{14}, and C_{17} acids gave positive but lesser growth. The C_8–C_{13} acids proved unsatisfactory substrates for the mold.

DEPARTMENT OF BOTANY AND BACTERIOLOGY,
UNIVERSITY OF ARKANSAS,
FAYETTEVILLE, ARKANSAS

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THE ISOLATION OF DERMATOPHYTES FROM THE ATMOSPHERE OF CAVES

H. I. Lurie and M. Way

The first report of a dermatophyte growing saprophytically in nature was that of Szathmáry (**11**) in 1936. He isolated *Trichophyton terrestre primum* (*T. gypseum*) from the mud of watercourses in the park of the University of Péco. One year later Muende *et al.* (**10**) found a colony of *Trochophyton* growing on horse dung. Since then *Microsporum gypseum* has been recovered from soil by Gorden *et al.* (**7**), Gordon (**6**), Ajello (**1, 2**), Durie *et al.* (**4**), Fuentes *et al.* (**5**), Lurie *et al.* (**8**) and Mandels *et al.* (**9**). In 1954 Ajello *et al.* (**3**) isolated *T. mentagrophytes* and *T. rubrum* from shoes which had been stored for 1 to 4 weeks and *Epidermophyton floccosum* from shoes recently worn by a sufferer from *tinea pedis.*

In 1955 Lurie *et al.* (**8**), while investigating the cause of "Cave Disease," isolated *Trichophyton mentagrophytes* from the soil of caves. We believe that the present report is the first record of the isolation of dermatophytes from the atmosphere.

One of the two caves from the soil of which *T. mentagrophytes* was isolated is Johnson's Pothole. This cave is completely uninhabited except for occasional visits by spelaeologists. A total of 42 animals, including monkeys, rabbits, guinea pigs, rats and mice, was taken into the cave to a depth of about 90 feet where they were left for about 5 hours, during which time a heavy dust was raised by the activity of the spelaeologists. The animals were then brought back to the laboratory where they were kept under observation. The rectal temperature of the larger animals was taken daily. Some of the animals were killed after 6 days and further batches every 2 or 3 days thereafter. Their lungs were removed under sterile conditions; portions were fixed in formalin and sectioned; small fragments were planted on dextrose agar and actidione medium; other portions were macerated by grinding gently with sterile, washed, river sand and suspended in normal saline. After allowing the sand to sediment, the supernatant fluid was planted on the same media and also injected intraperitoneally into 6 mice. Half of these mice were killed after 3 weeks and half after 6 weeks. Their livers and spleens were removed under sterile conditions. Portions were fixed in formalin and sectioned and portions were macerated and planted on dextrose agar and actidione medium.

No pathogenic fungi were recovered from the primary cultures of the lungs, but cultures of the livers and spleens of some passage mice resulted in the growth of dermatophytes. *Trichophyton mentagrophytes* was isolated from 8 of the total of 42 animals taken into the cave and *Microsporum gypseum* from one. In some instances the fungus was grown from the 3-week passage mice, in others from the 6-week passage mice and in 2 cases from both groups; and in all but one instance the fungus was grown from at least 2 of the 6 mice.

The animals yielding the *Trichophyton* included one monkey, killed 6 days after exposure, one rabbit and one guinea pig, killed 8 days after exposure, 2 mice killed 11 days after exposure, one guinea pig and 2 rats, killed 15 days after exposure. *Microsporum gypseum* was isolated from one monkey killed 11 days after exposure. Of 30 animals killed on or before the 15th day, 9 yielded a growth of a dermatophyte. No pathogenic fungi were isolated from the remaining 12 animals killed after the 15th day. Five of the 7 larger animals from which the dermatophytes were isolated were pyrexial and 2 were apyrexial. However, several other larger animals which were pyrexial yielded no pathogenic fungi.

Sections of the lungs showed the presence of an interstitial pneumonia. No fungal elements could be seen in sections stained with periodic acid Schiff stain. Neither pathogenic bacteria nor viruses were isolated from the fresh tissues. Direct cultures of the macerated lung tissue yielded no pathogenic fungi. Sections of the livers and spleens from which dermatophytes were isolated showed no obvious pathological changes and fungal elements could not be found.

DISCUSSION

The mode of infection of man by dermatophytes has always been a puzzle and our knowledge of the life cycle of these fungi is incomplete. It has been clearly shown that *Microsporum gypseum* and *Trichophyton mentagrophytes* can grow saprophytically in nature. This report now indicates that the spores of these fungi may be found in the atmosphere.

Two interesting facts emerge from this study, viz.

(a) These dermatophytes must be capable of multiplying at body temperature *in vivo,* as direct cultures were negative but passage resulted in a fairly profuse growth.

(b) They can survive for 8 weeks in the animal body at body temperature (15 days in the lungs of the animals exposed in the cave and 6 weeks in the passage animals).

It is problematical whether the pneumonia was caused by the der-

matophytes. No other organism was isolated but fungal elements were not observed in the sections and direct cultures of the lungs were negative.

SUMMARY

Trichophyton mentagrophytes and *Microsporum gypseum* have been isolated from the atmosphere of caves by exposure of laboratory animals and passage of their lungs through mice.

We wish to acknowledge the help given to us by Prof. J. F. Murray and the Transvaal Society of Spelaeologists who took the animals into the cave and supplied us with all the material. We are indebted to Dr. H. H. Malherbe for the virus studies, to Mr. P. Roux for the bacteriological examination and to Mr. D. Lloyd for preparing the sections.

THE SOUTH AFRICAN INSTITUTE FOR MEDICAL RESEARCH,
JOHANNESBURG,
SOUTH AFRICA

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HETEROTHALLISM, HETEROKARYOSIS, AND INHERITANCE OF BROWN PERITHECIA IN CERATOSTOMELLA RADICICOLA

ARIF S. EL-ANI, L. J. KLOTZ AND W. D. WILBUR

(WITH 11 FIGURES)

Ceratostomella radicicola, the perfect stage of *Chalaropsis,* was described by Bliss (**1**) as a new species. The imperfect stage is characterized by the production of two types of conidia: the hyaline endoconidia produced in endoconidiophores, and the dark, thick-walled macroconidia (macrospores) described by some mycologists as chlamydospores. The number of macroconidia differs from one medium to another, and the thallus color ranges from gray to black with increasing numbers of macroconidia. On potato-dextrose-yeast medium macroconidia are produced abundantly; hence the culture is black.

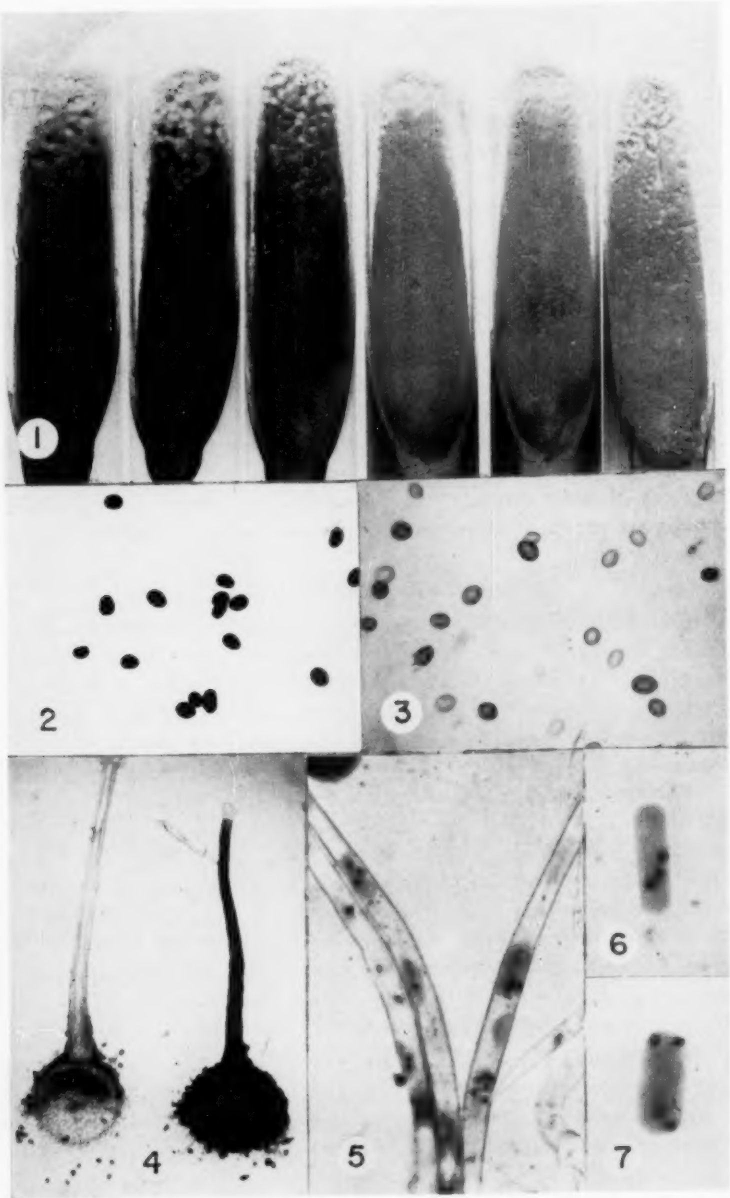
MATERIALS AND METHODS

Cultures of *C. radicicola* were grown on different media at 27° C. Of the many media used, Bacto prune agar (48 g per liter) and straw agar (**5**) were found to be the best for the formation of perithecia. Potato-dextrose-yeast medium (2 g of yeast extract per liter) was used for a clear and quick distinction between black and brown thalli, although the two types are also distinguishable on other media.

For cytological studies, materials were fixed in Carnoy's fixative (3 parts alcohol and 1 part acetic acid) for 48 hours. The aceto-orcein stain was employed. Because of the thick dark wall of the macroconidium, which rendered cytological observation difficult, the smear technique devised by Wilson (**14**) in studying the meiotic divisions in the meiosporangium of *Allomyces* was used. However, because of the small size of the macroconidia, their contents were not easy to press out.

HETEROTHALLISM AND HETEROKARYOSIS

Heterothallism was reported in *C. radicicola* by Bliss (**1**). He found that perithecia were produced along the line of union between 2 single conidium cultures. This, however, does not necessarily demonstrate heterothallism. Similar reaction was reported by Edgerton (**4**) in the



FIGS. 1–7.

homothallic fungus *Glomerella cingulata*. Recently, Olive (**11**) reported crossing among different isolates of the homothallic ascomycete *Sordaria fimicola*. Further investigations were therefore necessary to demonstrate whether or not the fungus *C. radicicola* is heterothallic.

Forty-two single endoconidium cultures were grown on the prune medium at 27° C and examined after 3 weeks for perithecia production. Twenty cultures were found to be self-fertile and 22 self-sterile. Likewise, out of 32 single macroconidium cultures, 26 were self-fertile and 6 were self-sterile. When single conidia were isolated from one of those self-fertile single conidium cultures, both self-fertile and self-sterile cultures were also obtained, but when single ascospore cultures were made from the same thallus, all were found to be self-sterile and cross-fertile. These observations seem to indicate that the fungus is heterokaryon.

Cytological studies of the nuclear condition have revealed that the endoconidiophore is multinucleate and that the nuclei are embedded solitarily or in groups in the vacuolated cytoplasm (FIG. 5). In the endoconidium the number of nuclei ranges from 1 to 5. Endoconidia with two (FIG. 8), three (FIG. 6) and four (FIG. 7) nuclei are very common. The multinucleate condition was also observed in the macroconidia (FIGS. 9, 10). The macroconidium arises at the tip of a conidiophore branch as a swelling in which the nuclei undergo mitotic divisions. It was at this stage, prior to the formation of the thick dark wall, that observation and counting of the nuclei could be made. At such an early stage it was possible to count eight nuclei or more in each macroconidium. Therefore, higher numbers of nuclei likely occur in the fully mature macroconidia. The fact that the proportion of macroconidia (81.2%) that give rise to self-fertile cultures is higher than that of the endoconidia (47.5%) is good evidence that the initial numbers of nuclei incorporated in the macroconidia are higher than those found in the endoconidia.

As the developing macroconidium enlarges, a thick wall that darkens with age, and a septum that cuts it off from the rest of the conidiophore, are formed.

Staining reveals that ascospores from the several crosses are uninucleate (FIG. 11). The nucleus of the ascospore is considerably smaller than that of the asexual spores; however, variation in size was

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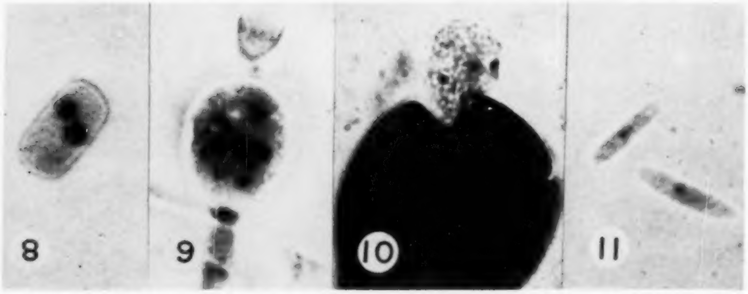
FIGS. 1–7. *Ceratostomella radicicola*. 1. Three cultures of the black strain and three of the brown. 2. Macroconidia from the black strain, × 200. 3. Macroconidia from the brown strain, × 200. 4. Brown (left) and black (right) perithecia, × 50. 5. Multinucleate endoconidiophores from the black strain, × 800. 6. Endoconidium with three nuclei, × 1800. 7. Endoconidium with four nuclei, × 1800.



FIGS. 8–11. *Ceratostomella radicicola.* 8. Endoconidium with two nuclei. 9. Immature macroconidium from the brown strain, showing dividing nuclei. 10. Mature macroconidium from the black strain, showing two nuclei in the cytoplasm that was pressed out. 11. Uninucleate ascospores. All × 1800.

also observed among nuclei in the endoconidia (compare FIG. 8 with FIGS. 6, 7). In contrast to the dense chromatic mass that represents the endoconidium nucleus, individual chromosomes and chromatic strands are often recognized in the ascospore nucleus (FIG. 11). The foregoing results therefore show beyond any doubt that the fungus *C. radicicola* is heterokaryon and that self-fertility of some of the single conidium cultures is due to heterokaryosis. Since the uninucleate ascospores give rise to hermaphroditic, self-sterile, and cross-fertile cultures, the fungus is heterothallic. The nuclear conditions in all respective parts of the brown strain (see below) are similar to those which are described above in the black strain.

INHERITANCE OF PERITHECIAL COLOR

In 1933, a new strain of *Chalaropsis* was isolated by Bliss (FIG. 1). It differs from the one thus far described (**1**) in producing brownish instead of black macroconidia (FIGS. 2, 3). In his notebook, in 1941, Bliss described the new strain as follows: "This culture for a year or more has been under some suspicion because of its brownish color. Examination indicated that the culture is pure, but that many of the macrospores are brownish. This variation is not explained."

In contrast to the black strain, the new isolate had never been seen to produce perithecia, thus its relation to the black strain *C. radicicola* was in doubt. Single and mass conidia grown on different media at different temperatures produced only self-sterile cultures. However, when a mass of conidia from this culture was mixed with a mass of conidia from *C. radicicola,* not only dark perithecia but also light-

brownish ones were produced (FIG. 4). Since brown perithecia had never been produced by the black strain, it was assumed that they were produced by the brown thallus. The question that arose was whether the brown perithecia resulted from cross-fertilization or from selfing of the brown strain. Single ascospore cultures made from those brown perithecia showed that the progeny of each consists of black and brown thalli. Therefore, the brown perithecia were produced as a result of cross-fertilization. When the ascospores from a few black perithecia were analyzed, the latter were found to be of two types: 1) perithecia from which all the ascospores gave rise to black cultures, and 2) perithecia from which black and brown cultures were obtained. Therefore, it is evident that the brown strain which has never been observed to produce perithecia by itself contains only one of the two compatible types of nuclei that occur in the black strain.

Crossing among single ascospore cultures has shown that each culture is hermaphroditic, self-sterile, and cross-fertile. There are two compatibility groups, A and a, and perithecia are formed when the two types are crossed. When 50 single ascospore cultures were made from one cross between a black and a brown thallus, 27 were found to be black and 23 were brown, a ratio of approximately 1:1. The brown strain, therefore, differs from the wild type (black strain) by a single allele. It is highly likely that the perithecial and macroconidial color is determined by the same gene, since among the few cultures tested all brown thalli produced brown perithecia.

Finally, it should be stated that no perithecium hyphae, particularly those of which the fringe is formed, were observed to produce endoconidia; this does not support the observation by Bliss (**1**). Under the microscope the ascospores can easily be distinguished from endoconidia by their shape and size (FIGS. 6, 7, 8, 11), and microscopic examinations of the mucous droplets at the ostioles have shown that only ascospores are present. Moreover, the ratio between black and brown cultures of the progeny from the crosses black × brown and brown × black was found to be the same, namely, 1:1. Had endoconidia been produced by the perithecium hyphae, a higher proportion of black cultures from the first cross and a higher proportion of brown cultures from the second cross would have been obtained.

DISCUSSION

The fact that brownish perithecia are produced by a new strain of *Ceratostomella* is particularly significant in regard to the taxonomy of the Pyrenomycetes. The separation of the Hypocreales from the

Sphaeriales made by Lindau (**7**) on the basis of color and consistency of the perithecial wall has been maintained up to the present time in most if not all textbooks of mycology. However, it has been repeatedly suggested that this separation is an artificial one. Indeed, Clements and Shear (**2**) and Miller (**9**) included all the Hypocreales as a single family, Hypocreaceae, in the Sphaeriales. Snyder (**13**) described the occurrence of both red and write perithecia in *Hypomyces solani* f. *cucurbitae* and emphasized the hazard in using color as a taxonomic criterion. *Ceratostomella* has been always known by its dark-walled perithecia with typical long beaks; thus it was placed in the family Ceratostomataceae, which was included in the Sphaeriales. The occurrence of brown and dark perithecia in the same species provides further evidence that color is not a reliable taxonomic character. Recently, several attempts have been made to revise the taxonomy of the Ascomycetes on the basis of the ascus wall and the internal structure of the ascocarps (**8, 10**).

Ceratostomella radicicola is a heterothallic fungus in which two compatibility groups, A and a, are recognized. Single ascospore cultures are hermaphroditic, self-sterile, and cross-fertile. The natural occurrence of *C. radicicola* as a miktohaplont was demonstrated in the black strain. Heterothallism was also demonstrated in *C. paradoxa* by Dade (**3**). The occurrence of self-fertile (homothallic) and self-sterile (heterothallic) strains in *C. fimbriata* was reported by Olson (**12**). Recently, Hansen and Snyder (**6**) described *C. fimbriata* as a hermaphroditic, self-fertile fungus in which two self-sterile mutants occur, the female and the male. When the two mutants are crossed, self-fertile hermaphrodites, females, males and neuters are producd. Such unisexual mutants in *C. radicicola* are under investigation.

SUMMARY

In the heterothallic ascomycete *C. radicicola* two compatibility groups, A and a, occur. Thalli that belong to one compatibility group or another are hermaphroditic, self-sterile, and cross-fertile. However, heterokaryosis was recognized in the black strain from which thalli of types A and a were isolated. A brown strain of *C. radicicola* produced brown perithecia when crossed with the compatible black strains. Ascospores from this cross gave rise to black and brown strains in 1:1 ratio.

DEPARTMENT OF PLANT PATHOLOGY,
UNIVERSITY OF CALIFORNIA,
CITRUS EXPERIMENT STATION,
RIVERSIDE, CALIFORNIA

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FUNGI ISOLATED FROM SOILS

John B. Routien

(with 2 figures)

The fungi that developed on various media employed for the isolation of microorganisms from a group of soils were examined and any that appeared unusual are reported here. A few that appear to be new are described, and all species hitherto not reported by Gilman (**4**) or more recent workers as being isolated from soil are listed.

MATERIALS AND METHODS

About 350 soils, chiefly from the United States, were examined. They were either plated out by using 0.4 ml of a suspension of 0.5 gm of soil shaken vigorously in 50 ml of sterile water or they were added to Petri dishes and covered with the medium following the method described by Warcup (**10**). One or both methods were used for any particular soil but only one method was used for any one of the media employed.

Though seven media were available, no more than five were used for any one soil. The composition of the media was as follows:

1. PDA—100 gms of peeled, sliced potatoes were steamed for 30 minutes in enough distilled water to cover them; liquid was poured off and to it were added 10 gms dextrose, 18 gms agar and enough distilled water to bring volume to 1 liter. Sterilization was at 20 lbs for 20 minutes.
2. PDRBA—prepared as above but with 67 mg Rose Bengal added before autoclaving. [This follows the method of Smith and Dawson (**7**).]
3. APDA—prepared as PDA but pH was adjusted to 5.5 before agar was added.
4. Warcup's—yeast extract 5 gms; $NaNO_3$ 3 gms K_2HPO_4 1 gm, $MgSO_4 \cdot 7H_2O$ 0.5 gm, KCl 0.5 gm, $FeSO_4 \cdot 7H_2O$ 0.01 gm, distilled water to make 1 liter; pH adjusted to 4; agar 25 gms. Sterilization at 20 lbs. for 20 minutes.
5. Grass decoction agar—50 gms of dried grass were autoclaved in 1 liter of distilled water for 30 minutes at 15 lbs. Material was

filtered through cheesecloth, 2 gms of K_2HPO_4 added, volume restored to 1 liter and pH adjusted to 6.2. 15 gms of agar were added and the medium was sterilized at 20 lb for 20 minutes.

6. DSM—asparagine 0.5 gm, dextrose 10 gms, meat extract 2 gms, K_2HPO_4 0.5 gm, distilled water to make 1 liter, adjusted to pH 5.5; sorbose 2 gms, agar 20 gms. Sterilized at 20 lbs. for 20 minutes.
7. XSM—malt extract 0.1 gm, yeast extract 0.1 gm, liver extract 0.1 gm, corn steep liquor 1 gm, dextrose 5 gms, distilled water to make 1 liter, pH adjusted to 4.5, sorbose 2 gms, agar 20 gms. Sterilized at 20 lbs. for 20 minutes.

The "soil plates" were incubated for several days at 28° C. Desired fungi were isolated by technicians to slants of malt extract agar for further growth. The cultures were identified and are discussed below.

RESULTS

NEW FUNGI. A fungus (FIG. 1A) designated as culture *17M962* was found to be an ascomycete belonging in the Aspergillaceae. Its characteristics, however, did not fit any genus so far described, so it is described here as a new genus.

Levispora gen. nov.

Cleistothecia sphaerica, sessilia, levia, astoma, fragilia, atra. Asci sphaerici vel subtriangulares, breviter stipitati, irregulariter dispositi, octospori, paraphysibus absentibus. Ascosporae sphaericae, unicellulares, leves, pallide olivaceae, in cumulo atrae.

Cleistothecia spherical, sessile, smooth, astomous, wall one cell thick, fragile, black from spores within, olive when empty. Asci spherical or somewhat triangular, with short stalk, distributed irregularly, without paraphyses. Ascospores spherical, single-celled, smooth, pale olive but black in mass, eight per ascus. Imperfect stage like a *Cephalosporium*. TYPE: *L. terricola.*

Levispora terricola sp. nov.

Coloniae in agaro e Solani tuberibus et dextroso composito crescentes mycelium tenue album rapide crescens efformantes. Status imperfectus generi *Cephalosporio* adscribendus. Cleistothecia abundantia, superficialia vel immersa, 100–135 μ lata. Asci numerosi, 6.5–10 μ diam. Ascosporae 2.5–4 μ, plerumque 3.5 μ, latae.

Colonies on potato-dextrose-agar forming a thin, white mycelium that grows rapidly. Surface of colony covered with short, colorless, vertical stalks arising directly from the mycelium and bearing heads of

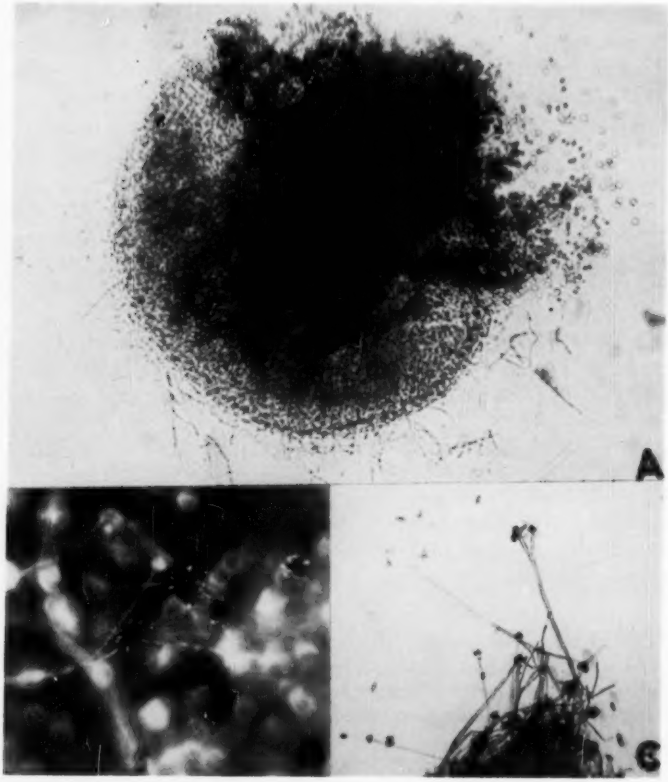

FIG. 1. A. Cleistothecium of *Levispora terricola*. B. Surface view of heads of spores of *Dactylaria lutea*. C. Conidiophores and spores of *D. lutea*.

spores arranged as in *Cephalosporium;* spores elliptical, hyaline, smooth, one-celled, 5.5–6.5 × 3.5–4 μ. Cleistothecia abundant, on the surface or immersed, 100–135 μ wide. Asci numerous, 6.5–10 × 6.5–10 μ, spherical or somewhat triangular. Ascospores 2.5–4 μ, usually 3.5 μ, wide.

Isolated from soil sample from Great Kills, New York, U.S.A. Type specimen deposited at Cryptoganic Herbarium, New York Botanical Garden, New York, N. Y. Culture *17M962* deposited at American Type Culture Collection and at Centraalbureau voor Schimmelcultures.

Another fungus, *Saturnomyces humicola,* with a *Cephalosporium* stage has been described (**1**), but the fungus here described is quite

different in shape and color of the ascospores. That the *Cephalosporium* stage is not a contaminant of *L. terricola* is evident from the fact that single spore isolates of the *Cephalosporium* all gave rise to cultures producing both *Cephalosporium* and *L. terricola* cleistothecia with asci and ascospores.

A second fungus (FIG. 1, B, C), as culture *16M974*, appeared to be a species of *Dactylaria*. The development of comparatively robust conidiophores and of spores not narrowed at both ends denies relationship with the predacious species of *Dactylaria*. This fungus has similarities to *D. orchidis* Cooke & Mass. but differs in having conidiophores branched, hyphae yellow, not golden, apex branched many times and spores colored. It seems to be a new species and is described below.

Dactylaria lutea sp. nov.

Coloniae in agaro e Solani tuberibus et dextroso composito crescentes pigmentum luteum efformantes. Conidiophora 2–3 mm alta, ad apicem 9–10.5 μ crassa, interdum ramosa. Sporae elliptico-fusoideae, aureae, denique brunneae, 2–4-septatae, plerumque 33–43 $\times$ 12–14 μ, in capitulo e sporis 6–12 composito productae.

Colony quickly formed on PDA with scanty, pale yellow aerial hyphae. A yellow soluble pigment is secreted. Conidiophores 2–3 mm high, 9–10.5 μ wide at apex, arising directly from mycelium in the agar. Long branches may develop near the apex of the conidiophore or short, nodulate branches may form, or the conidiophore may be unbranched. Conidiophores septate. Six to twelve or more short, nodulate branches at the apex give rise to spores in a head. Conidiophores colorless. Spores at first golden-yellow, then finally brown, elliptical-fusoid, often constricted at septa, 2–4-septate, smooth, blunt at both ends but distal end often with a short, sharp point. Spores mostly 2-septate, 24–33 $\times$ 10–13 μ and 3-septate, 20–53 $\times$ 11–16.5 μ (mostly 33–43 $\times$ 12–14 μ), less often 1-septate and 4-septate. Cells of spores about equal in size. Germinating at either or both ends.

Numerous dark brown to black sclerotia that resemble perithecia of *Fimetaria*.

Isolated from soil sample from Argentina. Type specimen deposited at Cryptogamic Herbarium, New York Botanical Garden, New York, N. Y. Culture *16M974* deposited at American Type Culture Collection and at Centraalbureau voor Schimmelcultures.

That the sclerotia were not contaminants was evident from the fact that when single spores were removed from the conidiophores and grown all resultant cultures had both the *Dactylaria* stage and the sclerotia.

FUNGI NOT PREVIOUSLY REPORTED FROM SOIL

All fungi that could be identified at least to genus and which, to the writer's knowledge, have not been reported from the soil are listed in TABLE I. Some are listed only to genus because of difficulty in identifications based on cultures alone of forms normally reported on dead or living materials. Some may be new species. An arbitrary numbering system is used to indicate that each soil is from a different locality.

The Ascomycetes listed in TABLE I agreed well with the descriptions of these species, but attention is called to a few. *Emericellopsis mirabilis* was first found by Peyronel growing on the surface of a camp site in Italy in 1948. Malan (**5**) reported this, and his isolation of the fungus in pure culture from the cleistothecia, in his 1952 publication. In our laboratory it developed on medium plated with a soil sample from Indiana.

Microascus trigonosporus was described by Emmons and Dodge (**3**) as a new species with a *Scopulariopsis* imperfect stage. It had been found as a contaminant in a superficial fungous infection of the feet and legs of a native of Puerto Rico. It is not astonishing, therefore, that we find it in a soil sample from El Salvador.

Muellerella nigra is a new species described by Routien (**6**). The other species of this genus are forms considered to be parasites on lichens and no one previously has reported isolating any from soil.

Among the imperfect fungi it was interesting that three species of the sometimes parasitic *Chaetomella* were isolated (and two pycnidial forms that were certainly *Chaetomella* but lacked setae were also found). *C. raphigera* was described as a new species on rose in New York and Virginia by Swift (**9**) in 1930. This same species is here reported from New York, Florida, Nigeria and Transvaal. That it actually was in the soils is quite probable because (1) no work involving this culture was being done in the laboratory, (2) it was not found in any of the numerous other soils there were being examined and (3) each of the four soils yielding this fungus was plated out at a different time over a period of 18 months.

The strain of *C. raphigera* discovered by Swift produced only pycnidia when it was grown on rose twigs, but Dodge (**2**) showed that with a high water content of the substrate he could also obtain sporodochia resembling the form genus *Hainesia*. By proper manipulation of the humidity he could induce the sporodochia to develop into pycnidia which did not have the raphe. The isolates studied here behaved as Dr. Dodge

TABLE I

Alphabetical listing of fungi isolated from soils. Except for two, none has been reported from soil previously.

Name	Soil number	Source of soil
Ascomyceteae		
Chaetomium aureum Chivers	1	Oklahoma
Chaetomium aureum Chivers	2	New York
Chaetomium brasiliense Bat. & Pont.	3	New York
Chaetomium seminudum Ames	4	Virginia
Chaetomium trigonosporum (Marchal) Chivers	5	Venezuela
Coniochaeta leucoplaca (Berk. & Rav.) Cain	6	Wyoming
Emericellopsis mirabilis (Malan) Stolk*	7	Indiana
Fimetaria humana (Fuckel) Griff. & Seaver	8	New York
Fimetaria humana (Fuckel) Griff. & Seaver	9	Transvaal
Fimetaria macrospora (Aurersw.) Griff. & Seaver	10	New York
Levispora terricola Routien	11	New York
Microascus trigonosporus Emmons & Dodge	12	El Salvador
Muellerella nigra Routien	13	Kentucky
Fungi Imperfecti		
Chaetomella atra Fuckel	14	Wyoming
Chaetomella oblonga Fuckel	15	New York
Chaetomella raphigera Swift	16	New York
Chaetomella raphigera Swift	17	Florida
Chaetomella raphigera Swift	18	Nigeria
Chaetomella raphigera Swift	19	Transvaal
Cordana pauciseptata Preuss**	20	New York
Curvularia inaequalis (Shear) Boedijn	21	New Hampshire
Curvularia inaequalis (Shear) Boedijn	22	New Hampshire
Curvularia maculans (Bancroft) Boedijn	23	New Jersey
Curvularia pallescens Boedijn	24	Arkansas
Curvularia pallescens Boedijn	25	Venezuela
Dactylaria lutea Routien	26	Argentina
Diplodiella sp.	27	Wyoming
Dothichiza sp.	28	Transvaal
Myrothecium roridum Tode ex Fries	29	New Jersey
Oothecium sp.	30	New York
Pestalotia sp.	31	Idaho
Pseudoseptoria sp.	32	New York
Volutina sp.	33	El Salvador

* *Peyronellula mirabilis* Malan was described as a new fungus (**5**) isolated from soil, but Stolk rightly transferred the species to the earlier described *Emericellopsis* (**8**).

** *Cordana pauciseptata* was isolated from soil of the Arboretum of the University of Wisconsin by Dorothy Fennell; this was reported in the mimeographed Mycological News Letter of the Mycological Society of America, Vol. V, no. 2, page 14, 1954.

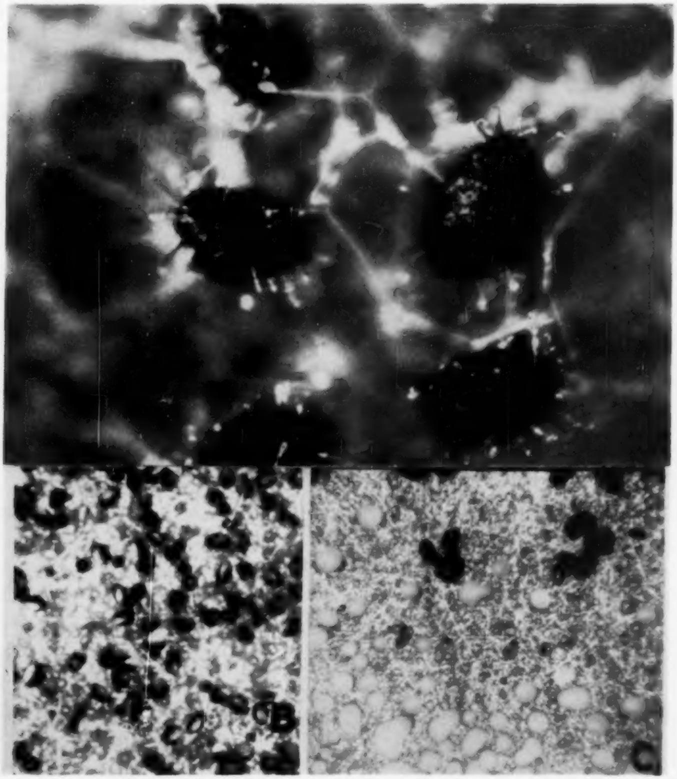

FIG. 2. A. Pycinidia of *Chaetomella raphigera* showing setae and raphe. B. Pycnidia of *C. raphigera* that have split open along the raphe. C. Pycnidia and sporodochia of *C. raphigera* developing side by side in Petri dish culture.

reported except that sporodochia never developed into pycnidia and splitting and opening of the pycnidia did occur (FIG. 2).

The *Volutina* appeared to be a new species because of the presence of reddish-orange stromata on which long, brown, coiled hairs formed. Sporodochia developed on the stromata. Unfortunately, measurements of spores were not made at the earliest opportunity and the culture very quickly ceased production of spores.

DISCUSSION

Seventeen fungi identified to species and an additional six identified to genus only were found for the first time in soils. Some of these were

found in several soils from different areas of the world. In some cases the data indicate that the fungus has a very wide distribution.

Data were not compiled to determine whether any particular medium or method was better than others. It was noticed, however, that many times the fungus would be found on two or more media. As a result of this it seems likely that none of the media used here is particularly better than another. It was clear, also, that the use of Warcup's technique in culturing fungi from the soil yielded more forms than did the usual plating out method.

ACKNOWLEDGMENTS

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SUMMARY

About 350 soil samples were examined for fungi by either plating out or using Warcup's technique. From one to five media were used. None of these media seemed to be best, but Warcup's method was better than the usual plating out method for obtaining fungi.

Nine Ascomycetes were identified that had not been reported before from soils. There were two more that had been reported only once quite recently.

Eight species of imperfect fungi not previously reported and one only recently reported were identified. Six isolates of different genera of the imperfect fungi were found but specific determination was not made.

A new genus, *Levispora*, in the Aspergillaceae, is described and a new species, *Levispora terricola*, is proposed.

Dactylaria lutea is described and proposed as a new species.

DEPARTMENT OF BIOCHEMICAL RESEARCH,
CHAS. PFIZER AND CO., INC.
630 FLUSHING AVENUE,
BROOKLYN 6, NEW YORK

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THE GENERA SERPULA AND MERULIPORIA

Wm. Bridge Cooke

In his treatment of *Merulius,* Burt (**1917**), following Fries (**1821**), divided the genus into the *Leptospori* with white spores, and *Coniophori* with "ferruginous, ochraceous or only very slightly colored spores." Other workers, from the time of S. F. Gray (**1821**) to the present, have considered most of the members of the second group as belonging to a different genus based on spore color, rather than to the same genus based on hymenial configuration. Gray called this genus, after Persoon, *Serpula.* Patouillard (**1897**) called it *Gyrophana,* revising his earlier *Gyrophora* which was preoccupied by a lichen genus. In studying several series of specimens of *Merulius* (in the sense of Fries and of Burt), the author came to the conclusion, expressed in an earlier paper (**1943**), that there are two distinct series of species represented. *Merulius,* based on *M. tremellosus* Schrad. ex Fr., would include the species with hyaline to slightly colored spores, while *Serpula* Pers. ex S. F. Gray, based on *S. lacrimans* Pers. ex S. F. Gray, would include species with dark colored spores. It appears that the species assigned to *Merulius* represent a series derived from some *Corticium*-like ancestor with *M. tremellosus* and *M. rubellus* as the most elaborate members of the series, while species assigned to *Serpula* represent a series derived from some *Coniophora*-like ancestor with *S. lacrimans* as the most specialized member of the series.

In a discussion of the taxonomic position of *Jaapia* Bres., Nannfeldt and Eriksson (**1953**) pointed out that it, *Coniophora, Coniophorella,* and *Serpula* form a natural series of genera. Donk (**1948**) erected the family *Coniophoraceae* for the last three of these. Donk stated that his *Coniophoraceae* was based on his earlier subfamily *Coniophoroideae.* However, according to Article 20 of the International Code of Botanical Nomenclature (**1952**), the type of a family is a genus, so that the family *Coniophoraceae* must be based on *Coniophora,* as the subfamily *Coniophoroideae* apparently was. To the four genera listed above as belonging to the *Coniophoraceae* of the Polyporales, two more should be added: *Gyrodontium* Pat. and *Meruliporia* Murr. Among the common characters of the family may be mentioned the basic hyphal system and the colored, smooth-walled spores whose inner wall may become stained with cotton blue.

Jaapia is hypochnoid with a smooth hymenium; *Coniophora* is corticioid with a smooth hymenium and without cystidia; *Coniophorella* is similar to *Coniophora* but with cystidia; *Serpula* is merulioid with weakly porose to strongly gyrose-plicate hymenium and without cystidia; *Gyrodontium* is hydnoid with densely crowded elongate spines over the tips of which the hymenium is confluent; and *Meruliporia* is poroid with true pores, a resupinate habit and no cystidia. Members of *Coniophora* and *Coniophorella,* if there are two genera represented in the complex, have not been monographed recently in North America; the treatment of Burt (**1917**) is the most recent. *Jaapia* has recently been monographed by Nannfeldt and Eriksson and is represented in North America: both known species are reported from Massachusetts and one species is listed from Idaho. *Meruliporia* is a monotypic genus restricted in distribution, so far as known, to the Western Hemisphere. *Serpula* is a wide-spread genus with species of great variability. *Gyrodontium* is a tropical genus which has not been critically studied since it was first proposed. *Coniophora, Serpula* and *Meruliporia* include species of great importance to people who build or own buildings made of wood. They include the "dry-rot" organisms.

In attempting to analyze the hyphal systems of these fungi, one must conclude that they are all monomitic, for all hyphal types throughout the fruit bodies of the group possess clamp connections. Simple clamps are the usual types, but medallion clamps and multiple clamps may be observed in some specimens. All fruit bodies possess "tertiary" or differentiated hyphae, hyphae which have colored or hyaline, thicker or gelatinized walls. Thus in this family all species have fruit bodies which are monomitic with clamp-connections and differentiated hyphae.

Cartwright and Findlay (**1946**), Nobles (**1948**), and Davidson and Lombard (**1953**) have discussed various cultural and physiological aspects of *Serpula lacrimans.* Davidson and Lombard (**1953**), and Baxter (**1940**) have discussed recent work on *Meruliporia incrassata.* It is interesting to note that the latter species is not known in Europe, while the former occurs commonly in Europe and possibly less so in North America. The extensive researches of Falck (**1912**) attest to the importance of the organism in Europe, while Ramsbottom (**1953**) indicates something of its importance in post-war England. These species cause extensive damage to structural timbers and various types of wood in construction situations. The occurrence of their fructifications on masonry, brick, tile, pottery, and other materials, including soil, indicates little, if anything, of the actual relationship of the mycelium to the habitat. *Coniophora puteana* (*C. cerebella*) is the other member of

this group which is of considerable importance because of the damage it can do to structural wood in buildings.

Of the group of species of *Serpula* described below, two are fairly common in temperate regions, one in tropical areas. Most cause mild to severe brown cubical rots in the wood in which they grow. The three commoner species are of economic importance in structural woods; the remainder are scavengers in the forest. From herbarium specimens it is difficult to tell the nature of the decay or the point of initiation of the growth of the fungus in the substratum. In the field, the only one of these which has been observed by the author is *S. lacrimans* var. *himantioides*. This species has always been found fruiting on sapwood just under loosening bark, on recently decorticated sapwood, or directly on bark. Logs have not been opened but in many cases it was noted that the fruit body was on solid wood and would be difficult to obtain if it were not readily separable. Dr. Nobles reports, in correspondence, that this is isolated frequently from decayed heartwood of standing timber.

The relationship between *S. lacrimans* var. *lacrimans* and var. *himantioides* is not always apparent in the field. According to herbarium specimens, until Burt described *Merulius americanus,* most specimens of both varieties were labeled *Merulius lacrymans* (sometimes spelled *lachrymans,* but rarely spelled as Fries originally spelled it, *lacrimans*). No one, including Bourdot and Galzin (**1927**), adopted Falck's name, *M. silvester,* for specimens not growing on structural timber of some sort. When the distinction was recognized, most workers assigned thin specimens growing on fallen logs and decaying wood in the forest to *M. americanus,* while the thicker specimens found on structural timber were labeled *M. lacrymans.* A case in point may be cited from southeastern Washington. A farm building within ten miles of Pullman had floor joists and flooring which had become badly decayed through the action of *S. lacrimans.* Within a half mile, in a ponderosa pine woodland, at least one fallen tree was found to have excellent fruiting of *M. americanus* in at least two different years. Only careful cultural studies can help in determining the extent of relationship of these forms.

Of the 650 specimens studied to date, 294 are assigned to *S. lacrimans* var. *lacrimans,* 203 to *S. lacrimans* var. *himantioides,* and 80 to *S. pinastri.* Anatomically, no significant differences have been observed between most of the fruit bodies of these species. An occasional specimen may apparently lack certain characteristics considered definitive in most cases. Morphologically there is no difference between the two varieties of the first species, and these differ from the second only in spore size. *S. pinastri* and *S. eurocephala* could be subdivided,

as *S. lacrimans* was, on the basis of apparent physiological activity. One group of specimens comes from "wild" habitats, occurring on rotting wood in the forest; another comes from structural timbers. The numbers of specimens available for study and the information on the specimens available to date indicate that such a separation is not feasible. *S. lacrimans* var. *lacrimans* and *S. lacrimans* var. *himantioides* are separated only on the basis of physiological activity. Their natural occurrence and growth in culture make a morphological separation impractical at the present time. Genetic studies are required to determine the degree of relationship between these two varieties, or between geographic races of each variety.

This paper is an attempt to present the species of *Serpula* and *Meruliporia,* so far as they can be understood, from the point of view of the herbarium taxonomist. Pure culture studies may later show some of the conclusions presented to be in error.

The curators of the herbaria listed here have cooperated in lending material for study (numbers of specimens studied from each collection follow the name of each herbarium) : National Fungus Collections (127), New York Botanical Garden (129), C. G. Lloyd Mycological Collection (71), Cornell University (60), University of Toronto (47), Missouri Botanical Garden (47), Science Service, Canada Dept. of Agriculture (46), L. O. Overholts Herbarium (37), Herbarium, University of California, Berkeley (31), University of Michigan (28), New York State Museum Herbarium (21), Pennsylvania State University (16), Michigan State University (1), Washington State College, Dept. of Plant Pathology (14), The State University of Iowa (13), Farlow Herbarium (18), Carnegie Museum, Pittsburgh (9), Wm. Bridge Cooke (22), Oregon State College (7), Donald P. Rogers (7), University of Florida (7), Forest Products Research Laboratories, England (5), University of Georgia (2), Harmsen (1).

Coniophoraceae Donk, Bull. Bot. Gard., Buitenzorg. III. **17**: 474. May 1948.

Polyporales. Spores two-walled, outer wall smooth, inner wall smooth, generally colored; setae absent; septa often verticillately clamped; medallion clamps present; fruit body soft; hymenophore smooth, tubercular, merulioid, gyrose-plicate, spinose to tubular.

TYPE GENUS: *Coniophora* DC. ex Pers.

Genera assigned to this family have, in the past, been assigned to the following families by various workers: *Thelephoraceae, Corticiaceae, Meruliaceae, Hydnaceae, Polyporaceae* and *Aphyllophoraceae.*

KEY TO GENERA

1. Hymenophore smooth...2
1. Hymenophore variously modified, not smooth when fresh.....................4
  2. Fructification hypochnoid...*Jaapia*
  2. Fructification corticioid...3
3. Hymenium without cystidia...*Coniophora*
3. Hymenium with cystidia..*Coniophorella*
  4. Hymenophore merulioid to strongly gyrose-plicate........................*Serpula*
  4. Hymenophore not merulioid...5
5. Hymenophore hydnoid, strongly spinose...................................*Gyrodontium*
5. Hymenophore truly polyporoid, tubular...................................*Meruliporia*

SERPULA Pers. ex S. F. Gray, Nat. Arr. Brit. Pl. **1**: 637. 1821.

Xylophagus Link, Mag. Ges. Naturf. Freunde, Berlin **3**: 38. 1809.

Merulius Pers. ex Fr., Syst. Myc. **1**: 328. 1821, pro parte.

Xylomyzon Pers., Myc. Eur. **2**: 26. 1825.

Gyrophora Pat., Hym. Eur. 143. 1887. Not *Gyrophora* Ach. 1803, Lichenes.

Gyrophana Pat., Cat. rais. pl. cel. Tunisie. 53. 1897.

Except for *Merulius,* these genera are obligate synonyms. In 1884, Karsten applied the name *Serpula* to this group without reference to Gray's earlier usage.

TYPE: *S. destruens* Pers. ex S. F. Gray (syn.: *M. lacrimans* Wulf. in Jacq. ex Fr.).

Receptacles resupinate, rarely pileate, membranous, floccose or fleshy; hymenium inferior, formed largely of pore-like alveoles, with edges obtuse and fertile; no cystidia; spores dark yellowish, rusty or brownish, ovoid to globose, rarely cylindric, apiculate, usually smooth, but verrucose in one species.

KEY TO SPECIES

1. Spores verrucose..*S. rugospora*
1. Spores smooth...2
  2. Spores larger, usually more than 8 μ long...........................3
  2. Spores smaller, usually less than 8 μ in length.....................6
3. Fruit body on soil, not associated with wood, erect.......................*S. erecta*
3. Fruit bodies on wood, soil or other substrata near wood...................4
  4. Fructification thick, sometimes reflexed, always on structural wood, soil or other substrata near such wood............*S. lacrimans* v. *lacrimans*
  4. Fructification usually thin, rarely thick, always resupinate, always on decaying logs and wood in open woodlands and forests..................5
5. Fructifications not on charred wood..............*S. lacrimans* v. *himantioides*
5. Fructification on charred wood ....*S. lacrimans* v. *carbonaria*
  6. Folds shallow, indistinct when dry......................................7
  6. Folds strongly gyrose-plicate to porose.................................10
7. Spores spherical..8

7. Spores ellipsoid to ovate, subcylindric or cylindric 9
   8. Spores 6–8 μ in diameter .... *S. illudens*
   8. Spores 5–6 μ in diameter .... *S. imperfecta*
9. Green and olive colors predominant in fresh material .... *S. atrovirens*
9. Yellow-brown to rusty colors predominant .... *S. byssoidea*
   10. On charred wood of *Sequoia sempervirens* .... *S. hexagonoides*
   10. Not on charred wood; on other hosts 11
11. Folds strongly porose, rarely gyrose-plicate .... *S. eurocephala*
11. Folds strongly gyrose-plicate, rarely porose 12
   12. Spores cylindric 13
   12. Spores subglobose to ovate 14
13. Fructification fuscous olive-yellow .... *S. crassa*
13. Fructification with reddish colors, especially when first dried .... *S. fusca*
   14. Fructification gelatinous, spores 3×4 μ .... *S. chlorinus*
   14. Fructification not noticeably gelatinous, spores larger 15
15. Spores reaching 6.5–7 μ in length .... *S. pinastri*
15. Spores 4.5–5.5 μ long .... *S. fuscescens*

SERPULA LACRIMANS Pers. ex S. F. Gray, Nat. Arr. Brit. Pl. 1: 637. 1821. var. **lacrimans**

Boletus lacrimans Wulf. in Jacq., Misc. Austr. **2**: 111, pl. 8, f. 2. 1781.

Merulius vastator Tode, Halle Naturf. Ges. Abandl. **1**: 351. 1783.

Sistotrema cellare Pers., Syn. Fung. 554. 1801.

Merulius destruens Pers., Syn. Fung. 496. 1801.

Xylophagus lacrymans (Wulf.) Link, Mag. Ges. Naturf. Freunde, Berlin **3**: 38. 1809.

Merulius lacrimans Wulf. in Jacq. ex Fr., Syst. Myc. **1**: 328. 1821.

Merulius brassicaefolius Schw. Naturf. Ges. Leipzig Schrist. **1**: 93. 1822.

Xylomyzon destruens Pers., Myc. Eur. **2**: 27. 1825.

Xylomyzon versicolor Pers., Myc. Eur. **2**: 30. 1825.

Merulius vastator Tode β *hydnoideus* Wallr., Flora Crypt. **2**: 623. 1833.

Merulius lacrymans var. *verrucifer* Quél. in Schulzer, Hedwigia **24**: 146. 1885.

Gyrophora lacrymans (Wulf.) Pat., Hymén. Eur. 143. 1887.

Merulius lacrymans fa. *terrestris* Ferry, Rev. Myc. **17**: 72. 1895.

Gyrophana lacrymans (Wulf.) Pat., Cat. rais. Pl. Cel. Tunisie 53. 1897.

Merulius lacrymans var. *terrestris* Pk., N. Y. St. Mus. Rept. **49**: 45. 1897.

Merulius guillemontii Boud., Soc. Myc. Fr. **10**: 63. 1894.

Merulius domesticus Falck in Möller's Hausschwammforsch. **6**: 53. 1912.

Merulius aurantiacus Klotzsch sensu Petrak, Flora Bohemiae et Moraviae exsiccata. II Serie—1 Abteilung: Pilze, Lfg. 19, Nr. 913.

Merulius terrestris (Pk.) Burt, Ann. Missouri Bot. Gard. **4**: 346. 1917.

Fruit body resupinate (usually) to occasionally pileate in the form of reflexed areas up to 10 × 5 cm, or a centrally stipitate structure, with rounded lobes up to 7 mm thick; fruit bodies widely effused, up to 30 × 15 cm or more, occasionally with stalactite formations; occasional specimens with poorly to well-developed rhizomorphs, rhizomorphs in one specimen up to 175 cm long, with a diameter of from 0.5 to 3.0 cm, averaging 1 cm, somewhat flattened against a solid surface, when near wood somewhat purplish, otherwise silvery, in cross section pseudoparenchymatic, with a hollow center, groups of cells merged to form single cell units, remnants of cell walls scattered in large cell units, tissue white, hyphae hyaline, resinous material in hollow center dark brown in Melzer's reagent; mycelial fans in herbarium specimens reaching 45 × 15 cm; next to the substratum the reverse shows lines radiating from the central point of fruit-body attachment; pilei, when present, with a brown tomentum, probably a trichoderm; context grey to pale cream or yellow brown, streaked with darker shades, more than 1 cm thick, with several well-defined areas of tissue; layer next to the substratum compact, with brown hyphae, 3.5–5.0 μ in diameter, with a very narrow lumen, becoming darker in KOH, layer 50–100 μ thick, hyphae yellow to brown, thick-walled, with simple clamps; yellow to brown hyphae occasionally with subspiral segments, multiple clamps sometimes present; next a layer of rather compact brown hyphae arranged more irregularly with few hyaline hyphae, 750–1500 μ thick; next a layer up to 1000 μ thick with predominant yellow to brown hyphae arranged more or less parallel with the substratum with intermingled irregular hyaline hyphae; next a layer 300–450 μ thick with irregularly arranged hyaline hyphae with some brown hyphae parallel with the substratum; subhymenium 2250 μ thick, with irregularly arranged hyaline hyphae, rarely incrusted, 3–4 μ in diameter, with clamps; hymenium whitish to yellowish at the margin, inside hymenium honey-yellow to dark-brown when dry, gyrose-plicate, porose-reticulate, becoming irpiciform in some areas, porose to the margin, or margin smooth for up to 1 cm, pores up to 1 cm deep; basidia clavate, 4-spored, 30–40 × 7–10 μ; spores golden-yellow in spore prints, yellow to golden-brown under the microscope, smooth, apiculate, narrow, ellipsoid, narrow ovoid, to ovate, flattened on one side, golden brown in KOH, (8–)9–11(–12.5) × (4.5–)5–7(–8) μ, sometimes with 2 oil drops.

Habitat and hosts: On masonry and woodwork in cellars, including bricks, earth walls, brick arches and masonry; all types of structural

wood including sills, foundation timbers, flooring, ceiling timbers, stringers, shelving, joists and beams over soil and cisterns; in greenhouses, sheds, root cellars, basements, barns, bowling alleys, churches, log cabins, dwellings; spreading out onto sandy, clay and dirt floors, burlap, flower pots and plants; on railroad ties and planks buried in soil and sand dunes; on packing cases, paper on shelves, coal stones, and other inorganic materials; on *Agave americana* (but probably not as host), *Picea sitchensis, Pinus* spp., *Pinus contorta* var. *latifolia, P. ponderosa, P. silvestris, P. strobus, Pseudotsuga taxifolia, Quercus* spp., and *Sequoia sempervirens* among others.

Specimens examined: EUROPE: France (9), Austria (13), Italy (8), England (13), Hungary (3), Germany (28), Czechoslovakia (10), Denmark (1), Belgium (1), Spain (1), Russia (3); ASIA: Caucasus (1), Japan (4); AUSTRALIA: (1); AFRICA: Union of South Africa (1); SOUTH AMERICA: Chile (1), Ecuador (2), Peru (1); NORTH AMERICA: Alaska (1); Alberta (6), British Columbia (2), Manitoba (4), Nova Scotia (4), Ontario (40), Quebec (7), Saskatchewan (4); Alabama (1), Arizona (1), California (28), Colorado (4), Connecticut (2), District of Columbia (4), Florida (2), Georgia (2), Illinois (7), Iowa (2), Kansas (3), Kentucky (2), Louisiana (6), Maine (1), Maryland (2), Massachusetts (28), Michigan (5), Missouri (9), Montana (3), Nebraska (1), New Hampshire (3), New Jersey (1), New York (33), North Carolina (1), Oregon (7), Pennsylvania (23), South Carolina (11), Utah (1), Vermont (1), Virginia (3), Washington (6), West Virginia (2), Wyoming (1).

Type specimens examined:

Merulius brassicaefolius Schw., ad parietinos in cryptis. Ravenel, Fungi Caroliniani Exsiccati, Fasc. 2, No. *23* (NY, CGL, NFC, FH, CU).

Merulius campbelli Cke. and Massee, Melbourne, Australia. Herbarium of G. Massee (NY). Nomen nudum. Not listed in Farlow Index according to I. M. Lamb.

Merulius lacrymans var. *terrestris* Pk. Alma, Michigan, October. Coll. by C. A. Davis (NFC, NYS).

Merulius (*Gyrophora*) *guillemotii* Boudier. ex ipso (Pat. FH).

Merulius lacrymans (Jacq.) Fr. var. *membranacea* P. Henn. "On wall in Gewoch's House, Berlin." From P. Hennings, Berlin Museum. Oct. 1902. Comm. G. F. Atkinson (CU).

It is of interest to note that in the Boston area, A. P. D. Piguet made collections of this species on the following dates: Apr. 23, 1903; Nov. 30, 1907; Aug. 18, 1911; Oct. 1917; Mar. 12, 1921; Oct. 22, 1921;

Jan. 7, 1929; Oct. 31, 1937; and Dec. 2, 1943; according to specimens housed in or distributed by the Farlow Herbarium. The fungus is reported as being fairly common in Juneau, Alaska. An undated clipping filed in the herbarium of the New York Botanical Garden shows an engraving of an apartment house, Holbrook Hall, 8 stories tall and 100 feet square which, after 4 years, was condemned because of extensive damage attributed to this fungus. The building was at the corner of 4th Ave. and 62nd St. in New York City.

In Burt's treatment of the group of species comprising the *Coniophori* of *Merulius,* five of the species are keyed out and described in such a way that almost any specimen belonging to the group could be keyed out to any of the five species. In the series of specimens borrowed through the courtesy of C. W. Dodge, Missouri Botanical Garden, specimens of these five species which were noted and autographed by Dr. Burt and cited or illustrated in his monograph were compared. Thickness or thinness of the fructification varies and the character of whether or not a specimen may be pileate is also variable, although only material assignable to *S. lacrimans* was found to be pileate. Hyphal characters were very constant throughout the group and all had clamped hyphae on which the clamps were simple, medallion or compound. Hyphal arrangement and context construction were similar throughout the group, but *S. lacrimans* had somewhat thicker fruit bodies. There were no sterile organs in the hymenium, and basidia were similar. Spore size is noted as variable by Burt, but within certain limits some of the species could be identified on this basis. However, it was felt that a study of spores from the five species could indicate something concerning the separation of species. A portion of the hymenium from each specimen was mounted and spores floated out in KOH-phloxine mounting medium. One hundred spores from one mount from a central area from each of the five autographed specimens were measured. The following table indicates that the range of variation in the average of the length and breadth of these spores is not sufficiently significant to be of specific value.

It is not in the province of this study to analyze these data further. Using techniques described by Parker-Rhodes (**1954**), it may be possible to analyze, on series of specimens, the deme structure within *Serpula lacrimans* to determine the extent and types of variation within this species. Such analyses should be made together with numerous physiologic and genetic studies to determine whether the single polymorphic species *S. lacrimans* is composed of numerous physiologic races or whether evolution has progressed far enough in it to enable us to

establish two or more species on bases other than the morphologic characters used here. More than one species may be indicated if unsuccessful monospore culture pairings are used as indicators of specific barriers. However, it is possible that between two or more physiologic races barriers exist which prevent successful monospore culture pairing. In this way it is possible that several named species may result from intensive study not only of *S. lacrimans,* but also *S. pinastri* and *S. eurocephala* which are equally polymorphic but much less commonly collected and are represented in North America herbaria by few specimens.

Falck (**1912**) recognized four species in the *"Lacrymans-Gruppe."* He called these *M. domesticus, M. silvester, M. minor,* and *M. sclerotiorum.* They were described in a series of comparative tables and figures. The first two fall in the range of spore size of the group of species listed above. The last two have smaller spores, comparable to those of *S. pinastri.* Falck used *"domesticus"* for *"lacrymans"* without explanation. Evidently he reserved *"lacrymans"* for a subgeneric category. As used, *"domesticus"* is illegitimate since *"lacrymans"* has priority. In the text, Falck referred to species by the species name only. In tables he usually added the initial of the genus *Merulius* before the species name. *M. silvester* corresponds to Burt's *M. americanus* and, having been validly published earlier, would take precedence over Burt's name had not a specimen from the type of Fries's *M. himantioides* been studied in the Lloyd collections.

Of the five species listed in TABLE I, *M. lacrymans, M. terrestris, M. brassicaefolius* and *M. himantioides,* according to Burt, are inhabitants of constructional timbers in buildings, mines, caves, greenhouses, etc. On the other hand, *M. americanus* is a "wild" form found only in the forest. Occasional specimens from both Europe and North America indicate that both groups of species can attack hardwood as well as wood from coniferous trees. The first group is of considerable economic importance in the wood construction industry, while the sec-

TABLE I

AVERAGE LENGTHS AND WIDTHS OF SPORES

Species (Burt's name)	Mo. Bot. Gard. No.	Length	Mean	Deviation	Width	Mean	Deviation
M. himantioides	54913	8.966		−0.61164	5.67		−0.22694
M. americanus	4061	9.1782		−0.39944	5.4936		−0.30334
M. terrestris	15861	9.7919	9.57764	+0.21426	5.8716	5.79694	+0.07466
M. lacrymans	9730	9.8406		+0.26294	5.9141		+0.11706
M. brassicaefolius	4070	10.1115		+0.53386	6.0354		+0.23546

ond, on the basis of fruiting material, is a scavenger of no commercial importance. So far as herbarium records go, it does not attack living trees but is found most frequently on sapwood before or after it has become decorticated. In a recent letter from Mildred K. Nobles it is indicated that cultures of the "wild" type have been obtained from decay in at least 11 species of North American coniferous trees.

Ramsbottom (**1953**) gives three colored photographs and considerable space to a discussion of the severity of this fungus in England. It is estimated that half the wooden buildings in London are infected by the fungus. Richards (**1953**) measured the number of spores of this fungus present in the air of a wooden house known to be infected with the fungus in wall paneling in a rear passage on the ground floor. Using slides, he collected spores as they fell from the air. Correcting for the number of spores present in a cubic meter of air he was able to give the following numbers:

2nd floor	390 spores per cu. m. air
1st floor	730
Ground floor	650
Basement	2100

Merulius guillemoti Boud. was placed as a form of *Gyrophana lacrymans* by Bourdot and Galzin (**1927**). From their description, it appears to be only the reflexed, imbricate form of the species.

SERPULA LACRIMANS var. **himantioides** (Fr.) var. nov. .

Boletus arboreus Sow., Eng. Fung. Pl. 346. 1803.

Merulius himantioides Fr., Syst. Myc. **1**: 329. 1821.

Xylomyzon versicolor Pers., Myc. Eur. **2**: 30. 1825.

Xylomyzon croceum Pers., Myc. Eur. **2**: 33. 1825.

Merulius papyraceus Fr., Elenchus **1**: 61. 1828.

Merulius squalidus Fr., Elenchus **1**: 62. 1828.

Merulius umbrinus Fr., Elenchus **1**: 61. 1828.

Merulius lacrymans var. *tenuissimum* Berk. in Rav., Fungi Am. 134. 1878. (n.n. Apparently used only as a name on an exsiccatum label.) Not *Merulius tenuissimus* Berk. & Br. 1883.

Gyrophora umbrina (Fr.) Pat., Hymén. Eur. 143. 1887.

Merulius tenuis Pk., N. Y. St. Mus. Rept. **47**: 147. 1894.

Hydnum pinastri Fr., Syst. Myc. **1**: 417. 1821, sensu Bres., Ann. Myc. **1**: 83. 1903.

Hydnum sordidum Weinm., Fl. Ross. 370. 1836, sensu Bres., Ann. Myc. **1**: 83. 1903.

Merulius silvester Falck in Möller, Hausschwammforsch. **6**: 53–55. 1912.

Merulius americanus Burt, Missouri Bot. Gard. Ann. **4**: 345. 1917.

Merulius polychromous Petch, Ann. Roy. Bot. Gard. Peradeniya **6**: 204. 1917.

Gyrophana umbrina (Fr.) Bourd. & Galz. sensu Bres. in Hymén. Fr. 353. 1928.

Merulius gelatinosus Lloyd, Myc. Writ. **7**: 1158. 1922.

Gyrophana himantioides (Fr.) Bourd. & Galz., Bull. Soc. Myc. Fr. **39**: 13. 1923.

Serpula americana (Burt) W. B. Cooke, Mycologia **35**: 284. 1943.

Fructifications single to confluent, forming large patches up to 10 × 100 cm, odor not apparent to strong; usually up to 500 μ, sometimes up to 700 μ thick, sometimes rhizomorphic; when fresh more or less fleshy to tremelloid, at least in the areas close to the hymenium; hyphal layer next to the substratum with hyaline and brown hyphae parallel with the substratum, 120 μ thick, subhymenial layer appearing partly gelatinized, loosely arranged, parallel with the substratum but without brown hyphae, near the hymenium forming a denser layer perpendicular to the substratum, about 150 μ thick; brown hyphae 5–8 μ in diameter, hyaline hyphae 2–5 μ in diameter, both types sometimes incrusted, both sets with simple or compound clamps; hymenium gyrose-plicate to gyrose-porose, pores up to 5 mm across and from 0.5–5 mm deep when labyrinthiform, when shallow, net-like, more or less irregularly arranged, when young, very shallow, grey, then gold to cinnamon, olive or dark brown, when dry honey-brown, with a white margin and subicular layers easily separable from the substratum in large sheets; basidia averaging 36 × 7.3 μ, with 4 sterigmata, sterigmata 7.2 μ long; spores tawny or light brown in a KOH-phloxine mount, ovate, flattened on one side, apiculate, (7–8–)10–11.5(–12) × (4–)5–7(–8) μ. When fresh, some specimens are heavily infested with beetles which devour the collection unless fumigated when collected.

Habitat and hosts: On litter and rotten wood, as well as on decaying wood of the following hosts: *Abies* sp., *A. concolor, A. magnifica* var. *shastensis, Alnus oregona, Betula* sp., *B. alba* var. *papyrifera, Castanea dentata, Cedrus deodara, Fagus silvaticus, Larix americana, L. occidentalis, Liriodendron tulipifera, Melia azederach, Picea* sp., *P. engelmannii, P. excelsa, Pinus* sp., *P. banksiana, P. communis, P. echinata, P. monticola, P. ponderosa, P. rigida, P. silvestris, P. strobus, P. virginiana, Populus* sp., *Pseudotsuga taxifolia, Quercus* sp., *Thuja plicata, Tilia americana, Tsuga canadensis, T. mertensiana, Ulmus* sp.

Specimens examined from: EUROPE: Denmark (3), Austria (6),

Latvia (1), Sweden (8), England (3), Finland (2), Belgium (1), Germany (7), France (2), Hungary (1), Czechoslovakia (3); ASIA: Ceylon (1), Pakistan (1); AFRICA: Union of South Africa (1); NORTH AMERICA: Cuba (1); "Canada" (2); British Columbia (4), Nova Scotia (3), Ontario (37), Quebec (1), Alabama (3), California (34), Colorado (3), District of Columbia (1), Florida (1), Georgia (2), Illinois (2), Iowa (9), Idaho (5), Kentucky (1), Louisiana (6), Maine (1), Maryland (2), Massachusetts (7), Michigan (4), Missouri (1), Montana (1), Nevada (1), New Jersey (1), New Mexico (1), New York (30), New Hampshire (1), North Carolina (2), Ohio (1), Oregon (5), Pennsylvania (18), Tennessee (1), South Carolina (5), Virginia (1), Washington (13), West Virginia (9), Wisconsin (2), Wyoming (2).

Type specimens examined:

Merulius polychromous Petch, Habgalla, Ceylon, May, 1913, T. Petch *3769* (CGL).

Merulius lacrymans (Jacq.) var. *fragricus* Ell. & Ev., on old logs, Race Course, near Ottawa, Ontario, Nov. 10, 1890 (NY).

Merulius lacrymans Fr. var. *tenuissimum* Berk. & Rav. in ligno Pini, Aiken, S. Car., H. W. Ravenel, in Fungi Americani Exsiccati No. *134* (CU, NFC, NY).

Merulius himantioides Fr. "Ex Fries from Kew" (CGL *19959*).

Merulius gelatinosus Lloyd, growing over leaves and debris. Miss A. Duthie, Africa (CGL *19979*).

Merulius tenuis Pk., Ithaca, New York, W. R. Dudley (NYS).

Bourdot and Galzin (**1928**) include *Gyrophana umbrina* (Fr.) Bourd. & Galz. in the sense of Bresadola, not of Burt and *Gyrophana himantioides* (Fr.) Bourd. & Galz. as separate and distinct species based on specimens collected from "wild" habitats. Their similarity with *Gyrophana lacrimans* is mentioned.

SERPULA LACRIMANS var. **carbonaria** (Lloyd) var. nov.

Merulius carbonarius Lloyd, Myc. Writ. **6**: 963. 1920.

Resupinate, up to 1.5 cm thick, context light brown, hymenium black; when dry folds shallow, irpiciform to raduloid or merulioid, with very few spores still attached, no free spores; basidia collapsed, no cystidia or setae, spores (few seen) $9 \times 4\,\mu$, brown; no conducting organs seen. Tissue below the subhymenium loosely interwoven, with frequent knots of hyphae; hyphae separate or forming ropes which anastomose and branch; remainder of fructification formed of compactly arranged hyphae, hyaline or pale yellow, thick-walled to solid, with clamps; reverse filling cracks in rotten, burned, carbonized wood.

Type and specimen examined: On old log, Montesano, Washington, collected by J. M. Grant, Mar. 1919 (NFC, Farl., CGL *9930*).

Because of its thick context, unusual hymenophoral configuration, and rather small spores, this specimen is retained as a variety of *S. lacrimans*. Fresh material may indicate something more concerning the proper position of this variety.

In publishing this species, Lloyd noted that the thick fruit body could have resulted from the unusual habitat, that he saw occasional thick-walled, hyaline cystidia and that there were elongated cells in the hymenial tissue which carried the coloring matter. He also indicated that he did not see the "hyaline" spores. The writer has not seen hyaline cystidia nor colored conducting organs, but a few colored spores were in evidence.

Serpula pinastri (Fr.) comb. nov.

Auricularia pulverulenta Sow., Eng. Fung. Pl. 214. 1799.

Hydnum pinastri Fr., Obs. Myc. **1**: 149. 1815.

Hydnum pinastri Fr. ex Fr., Syst. Myc. **1**: 417. 1821.

Coniophora membranacea β leioplaca Pers., Myc. Eur. **1**: 153. 1822.

Coniophora membranacea DC. ex Pers., Myc. Eur. **1**: 153. 1822.

Xylomyzon taxicola Pers., Myc. Eur. **2**: 32. 1825.

Merulius pulverulentus Fr., El. Fung. 60. 1828.

Hydnum sordidum Weinm., Fl. Ross. 370. 1836.

Polyporus (*Resupinatus*) *chrysobaphus* Berk. & Curt., Grev. **1**: 53. 1872.

Merulius candicans Roumeguère, Rev. Myc. **8**: 15. 1886.

Merulius irpicinus Pk., N. Y. State Mus. Rept. **47**: 146. 1894.

Merulius himantioides sensu Bres., Ann. Myc. **1**: 83. 1903. Not Fr. 1821.

?Merulius hydnoides Henn., Hedw. **42**: 178, 183. 1904.

Merulius pinorum Britz., Revis. Hymenomyc. 212. 1909.

Merulius minor Falck, in Möller's Hausschwammforsch. **6**: 53–55. 1912.

Merulius pinastri (Fr.) Burt, Ann. Missouri Bot. Gard. **4**: 356. 1917.

Gyrophana pulverulenta (Fr.) Bourd. & Galz., Hymén. France 353. 1928.

Gyrophana pinastri (Fr.) Bourd. & Galz., Hymén. France 355. 1928.

Merulius tignicola Harmsen, Friesia **4**: 245. 1952.

Fructification resupinate, 2–4 cm in diameter, adnate or separable, reverse with same color as hymenium; hyphae hyaline to yellowish, loosely interwoven, 3–5 to 6–8 μ in diameter; inner tissues closely interwoven, irregularly arranged, toward the substratum the cells thick-walled, context 300 μ thick; hyphae forming rope-like strands near the substratum in some specimens, reaching 20 μ in diameter; hyphae thin- to thick-walled, sometimes granule-incrusted; hymenium cream to antimony-yellow, greenish-yellow or ochraceous buff when fresh, becoming olive-green to yellow-brown when dry, margin cottony to smooth, as the hymenium develops becoming wrinkled, folded, or plicate, irregularly porose, becoming somewhat dentate to strongly irpiciform in some specimens, with pore-like areas 0.5–3 mm in diameter, 1–3 mm deep, folds rarely extending to margin, clamps at infrequent septa; basidia 18–20 × 4–5 μ, with 4 sterigmata; spores smooth, ovate to subglobose, apiculate, golden to yellow-brown, 4.5–6.5(–7) × (2–)3–5 μ.

Habitat and hosts: On rotting wood of *Abies pectinata, Alnus* sp., *Larix americana, L. occidentalis, Picea* sp., *P. excelsa, Pinus* sp., *Pinus ponderosa, P. silvestris, P. virginiana, Populus trichocarpa, Pseudotsuga taxifolia, Quercus* sp., *Thuja plicata, Umbellularia californica;* on structural wood used in cellars and buildings, on rotten wood in cases, on the ground in greenhouses and cellars near wood, on pine boxes, flats and other wood, and on compost in a mushroom bed.

Specimens examined: EUROPE: France (3), Hungary (1), Czechoslovakia (1), Sweden (2), Latvia (2), Austria (3), Italy (1), Denmark (5), Germany (5), England (3), Belgium (1); AUSTRALIA: (1); SOUTH AMERICA: Brazil (1), Ecuador (1); NORTH AMERICA: British Columbia (1), Ontario (5); Arizona (1), California (2), Colorado (1), District of Columbia (1), Indiana (1), Iowa (2), Idaho (7), Illinois (1), Kentucky (1), Louisiana (2), Maine (3), Massachusetts (6), Maryland (1), Montana (1), Michigan (1), Missouri (4), Nebraska (1), New Hampshire (1), New York (2), Ohio (2), Oregon (1), Pennsylvania (2), Tennessee (1), Vermont (1), Washington (2), West Virginia (1).

The combination *Merulius chrysobaphus* (Berk. & Curt.), attributed to Bresadola, does not appear in the Farlow Index, according to I. M. Lamb, and may never have been made.

Types have been examined of the following species:

Merulius candicans Roumeguère, on the ground and wood, near Brussels, Belgium. Oct. 1885. Collected by El Marchal. C. Roumeguère, Fungi Callici exsiccati *3503* (NYBG).

Merulius irpicinus Pk., on old log, Fall Creek, Ithaca, N. Y. October (NYS).

Merulius subchlorinus Ell. & Langlois, in herb. (NFC, NY). Pointe à la Hache, Louisiana. Dec. 30, 1886. A. B. Langlois *976*. Under a rotting log in a willow jungle. Nomen nudum.

Merulius tignicola Harmsen, Friesia **4**: 245. 1952. Harmsen *1391*. Fuglebjerg, Denmark. Collected by Harmsen, Mar. 16, 1945 (FH).

Merulius umbrinus Burt not Fr. is included as a synonym of *Gyrophana pulverulenta* (Fr.) Bourd. & Galz. by Bourdot and Galzin (**1928**). According to them, Bresadola thought that the name as used by Fries referred to a species with large spores, while Burt applied it to a species with small spores.

This species among the small-spored species of *Serpula* could be artificially divided into two groups based on habit. These would correspond to the two principal varieties of *S. lacrimans* recognized above. However, study of cultural characteristics and the comparative reaction of strains in various habitats as well as pairing of monosporous mycelia must be made before this species can be better understood. Separate reactions of strains or physiological races in these species is not considered of sufficient importance for establishment of species.

Morphologically and anatomically the authentic specimen of *Merulius tignicola* kindly loaned by L. Harmsen agreed with the 87 specimens of *S. pinastri* which had been seen. This species, therefore, is placed in synonymy with *S. pinastri*, as is *M. minor* Falck which here is considered a validly published species.

Serpula eurocephala (Berk. & Br.) comb. nov.

Polyporus eurocephalus Berk. & Br., Jour. Linn. Soc. **14**: 48. 1875.

Merulius similis Berk. & Br., Jour. Linn. Soc. **14**: 58. 1875.

Polyporus sulfureus Fr. sensu Berk. & Br., Jour. Linn. Soc. **14**: 48. 1875.

Merulius giganteus Sauter, Hedwigia **8**: 73. 1877.

Merulius tessellatus Bres., Bull. Soc. Myc. Fr. **6**: xlvii. 1890.

Merulius subambiguus Henn., Hedwigia **36**: 202. 1897.

Merulius pseudolacrymans P. Henn., Hedwigia **40**: 328. 1901.

Merulius eurocephalus (Berk. & Br.) Petch, Roy. Bot. Gard. Peradeniya Ann. **4**: 408. 1910.

Merulius sessilis Berk. & Br. f. *pileata* Bres., Ann. Myc. **10**: 508. 1912.

Merulius binominatus Massee, Kew Bull. Misc. Inf. **1913**: 104. 1913.

Merulius insignis Wakefield, Kew Bull. Misc. Inf. **1917**: 107. 1917.

Merulius consimilis Lloyd, Myc. Writ. **7**: 1122. 1922.

Fructification rarely resupinate to commonly applanate, developing from living or dead bamboo wood, poles or sticks, or from dead wood in the forest; upper surface pale yellow to brown, formed of a cortex appearing incrusted or not, nearly laccate in some specimens, at first a trichoderm, formed of densely interwoven brown context hyphae 2–3 μ in diameter; context white to light brown, up to 1 cm thick, formed of hyaline to yellowish or brownish hyphae, not apparently gelatinous, mostly with simple clamps, 1.5–4 μ in diameter; hymenium dark yellow, orange, light brown or brown, gyrose-plicate, the folds close together and regular, simulating tubules which may reach 5 mm in depth but with the hymenium continuous over the surface of the folds; basidia 14.4 $\times$ 7.2 μ, mostly 4-spored, no cystidia; spores yellow-brown, smooth, apiculate, flattened on one side, 4–6 $\times$ 3–4 μ.

Habitat: On living and dead *Bambusa* spp. in the "wild," on bamboo used in construction of buildings; and on rotten wood of such species as *Leucaena glauca*.

Specimens examined: AFRICA: Portuguese West Africa (1); ASIA: Ceylon (2), French Indo-China (4), Java (2), India (1), Malaya (3), Philippines (2); SOUTH AMERICA: Brazil (2). Also reported from: Austria, Southern Nigeria, and Queensland, Australia.

Cunningham (**1950**) placed *M. giganteus* Sauter in synonymy with *M. lacrymans*. Evidence appears to indicate that it is better classed with *S. eurocephala* at least until typical material from Austria can be studied more critically.

Merulius insignis Wakefield is placed here on the basis of the original description and on Lloyd's notes (Myc. Writ. **7**: 1272. 1924). *Merulius giganteus* Sauter and *M. pseudolacrymans* P. Henn. are included on the basis of Lloyd's notes (Myc. Writ. **5**: L. 67: 15. 1918). *M. giganteus* may better be included in *S. pinastri* on the basis of its habitat, distribution and Hennings' memorandum cited by Lloyd.

Merulius tessellatus Bres. is included here although Bresadola gave the spore size as 7–9 $\times$ 6 μ. The description and illustration indicate that the species is a synonym of *S. eurocephala*.

Petch (**1910**) gives the best published description of the habitat of this fungus.

Type specimens examined:

Merulius consimilis Lloyd, Philippines (CGL *26984*).

Merulius subambiguus P. Henn., Brazil (NFC).

The combinations *Gyrophana similis* (Berk. & Br.) Pat. and *G. pseudolacrymans* (P. Henn.) Pat., picked up in synonym lists, do not appear in the Farlow Index according to Dr. I. M. Lamb. It is possible they were never made.

Serpula rugospora sp. nov.

Merulius rugosporus Lloyd, in herb.

Pileus tenuis, gyroso-pliciformis, margine fimbriatus, pallide brunneus; hyphis hyalinis vel luteo-brunneis; basidiis $14.4 \times 7.2\,\mu$; sporis luteo-brunneis, apiculatis, verrucosis, ovatis vel subglobosis, 5–6 μ diam. vel $4.5–6.5 \times 5.5–7.5\,\mu$.

Fructification thin, gyrose-plicate, margin narrow, folds starting almost immediately, margin somewhat fimbriate, light tan; hyphae hyaline to yellow or yellow-brown, loosely interwoven, sometimes incrusted, with clamps; basidia $14.4 \times 7.2\,\mu$, with 4 sterigmata; spores yellow-brown, flattened on one side, apiculate, verrucose, ovate to subglobose or globose, 5–6 μ in diameter, or $4.5–6.5 \times 5.5–7.5\,\mu$, wall up to 1 μ thick.

Habitat: On rotten wood.

Type and specimen examined: Kentucky: Crittenden. Aug. 1920. Collected by C. G. Lloyd. CGL *5804,* LOO. TYPE.

This specimen is considered distinct from *S. pinastri* because of the verrucose spores. A portion of this type specimen was sent by Lloyd to Overholts in 1925. Overholts also accepted the verrucose spores as belonging to this fungus. In some circumstances, verrucose spores are considered a sufficient basis for erecting a new genus. In this case, with only one specimen available for study, this is not considered justifiable.

Serpula illudens Overholts, sp. nov.

Merulius illudens Overholts, in herb.

Pileis resupinatis effusis, mebranaceis, avellaneis vel brunneis, hymenio meruloidea; sporis globosis, pallide luteo-brunneis, 6–8 μ diam.

Resupinate, effused, at first forming a thin, white membrane that becomes avellaneous or avellaneous-brown as the hymenium develops, decidedly brown at maturity and when wet, pale on drying, marked with irregular and indistinct merulioid folds when dry, when wet swelling to a distinctly merulioid condition; in section 160–400 μ thick, rather distinctly 2-layered, with a hyaline layer of longitudinal hyphae, loosely arranged, granule-incrusted in lactic acid (not in KOH), about 120 μ thick, the hyphae 2–4 μ in diameter, then a heavily gelatinized layer about 100–150 μ thick in which the hyphae are obscured by numerous brown spores similar to the basidiospores; basidiospores globose, rather thick-walled, pale yellowish-brown, 6–8 μ in diameter; cystidia none.

Habitat: On dead twigs of coniferous branches on the ground (probably on *Tsuga canadensis*).

Distribution: Tennessee: Mount Le Conte, Great Smoky Mountains

National Park, 4000 ft., Sept. 11, 1935, collected by A. J. Sharp. Univ. of Tennessee *8348*, LOO *19127* (TYPE).

The above description was drawn from Dr. Overholts' notes and confirmed by the writer. Dr. Overholts further noted: "Until this is wetted up it is likely to be taken for a *Coniophora,* but in fresh condition the hymenium is distinctly and continuously merulioid but not at all poroid. The peculiar avellaneous-brown coloration, the presence of a broad, medianly placed, gelatinous layer in the subiculum, and the globose spores of the sizes indicated should make this an easily recognized species."

From the number of other specimens seen in this group of merulioid fungi this is recognizable largely from the globose spores. The other characters occur in one degree or another in all other species of which several specimens have been seen.

Serpula imperfecta Overholts, sp. nov.

Merulius imperfectus Overholts, in herb.

Pilei resupinati, effusi, membranacei, avellanei vel brunnei, hymenio laevi vel incomplete obsoleteque porosa; sporis globosis, brunneis, 5–6 μ diam.

Entirely resupinate, effused in elongated patches 10 cm or more long, 3–6 cm broad, more or less separable, membranaceous, with a very narrow white border that may eventually disappear; hymenial surface avellaneous with a purplish cast in fresh specimens, close to very dark "cinnamon drab" (R), drying considerably paler and scarcely darker than isabelline, forming very imperfect pores 0.75–1.5 mm in diameter only outlined by slight reticulations but persistent in dried specimens; in section 450–800 μ thick, composed of 3 annual (?) layers each 150–225 μ thick and each showing a dark hymenial layer and a context composed of longitudinally interwoven, nearly colorless or only slightly tinted hyphae that are septate and clamped and 2–2.5 μ in diameter, without incrustation or gelatinification; hymenial layer 32–50 μ thick, dark brown in color in KOH; spores globose, brown, 5–6 μ in diameter, smooth; cystidia none; basidia 8–10 μ in diameter.

Habitat: On old log of *Tsuga canadensis.*

Specimens examined: Pennsylvania: Reetz Gap, Center Co., Oct. 10, 1939. Collected by L. O. Overholts. LOO *22178* (TYPE). West Virginia: Short Creek, 1800 ft., Fayette Co. Collected by L. W. Nuttall, *1399,* Feb. 8, 1894. (J. B. Ellis *355.*) Filed at the University of Michigan Herbarium.

The above description was drawn from Dr. Overholts' notes and confirmed by the writer. In addition Dr. Overholts noted: "The slight

degree of development of the pores would make it possible that the species has been described in *Coniophora*, but I find no species of that genus that seem to fit. The dark hymenium, the pallid context, the globose and colored spores seem to be the distinguishing characters of the species. It is not related to the *M. lacrymans* group."

This species differs from *S. illudens* only in the smaller spores and the lack of a gelatinous layer. The appearance of an apparent perennial condition is unusual but may be a habitat response. A wider series of specimens of this type from the Alleghany Mountain area may connect these two species with the more common members of the genus. Crossed monosporous mycelia may yield a clue as to its relationships.

Serpula erecta (Lloyd) comb. nov.
Merulius erectus Lloyd, Myc. Writ. **6**: 1049. 1920.

Fructification erect, imbricate, appearing like a *Tremellodendron*, but composed of *Serpula*-like tissues; tissue brown, composed of clamped and interwoven but basically parallel hyphae; gyrose-plicate folded hymenium covering outer surfaces of pileus, becoming decurrent downward to the soil level; basidial layer in poor condition but basidia apparently 4-spored, 25–30 × 7–9 μ; spores brown, smooth, ovate, apiculate, 8.5–9.5 × 5.4–6.3 μ.

Habitat: On soil.

Type and specimen examined: Minneapolis, Minnesota. Collected by Dr. M. S. Whetstone (CGL *19956*).

This specimen is retained as a species distinct from *Serpula lacrimans* var. *lacrimans* because of its erect habit and reported habitat. If the specimen was obtained from the basement of a house or from the earthern floor of a shed or barn where it could have originated from mycelium using structural timber, this disposition would be in error and the species would become a synonym of the common dry-rot organism.

Serpula atrovirens (Burt) comb. nov.
Merulius atrovirens Burt, Missouri Bot. Gard. Ann. **4**: 359. 1917.

Fructification resupinate, 3–8 × 2–4 cm, effused, membranaceous, separable, drying between dark green and dark olive grey in the central region, bordered by obscure wood brown, the margin whitish and thinning out; hymenium at first reticulate-plicate, at length porose with angular pores about 1–1.5 mm deep and about 1.5–2 to a mm; in structure 400–600 μ thick with (1) the layer next to the substratum composed of loosely interwoven, somewhat colored hyphae 3 μ in diameter,

occasionally nodose-septate, incrusted and with (2) a broader layer extending to the hymenium, with hyphae densely interwoven and hyaline; no cystidia; spores citron-yellow under the microscope, even, 4.5–5 × 3–3.5 μ.

Habitat: On underside of half-decayed log of *Liriodendron tulipifera*.

Type and specimen examined: North Carolina: along Caney River, lower slopes of Mount Mitchell, Yancey Co., 3000–4000 ft., Sept. 15–16, 1901. Collected by G. F. Atkinson (MBG *55041*).

Serpula byssoidea (Burt) comb. nov.

Merulius byssoideus Burt, Missouri Bot. Gard. Ann. **4**: 358. 1917.

Fructification resupinate, 3 × 2 cm, effused, dry, waxy, drying between Saccardo's umber and Dresden-brown throughout, separable from the substratum, the margin rather thick and undulate; hymenium minutely rugose-porose, with very slightly elevated, thin folds which outline the rather imperfect, shallow pores about 2–4 to a mm; in structure 300–400 μ thick, with folds extending about 400 μ more, composed of loosely interwoven, thin-walled hyphae 3–4.5 μ in diameter, occasionally nodose-septate, having the general color of the fructification but losing their color by solvent action of the alcohol when being sectioned, hyaline hyphae sometimes gelatinously thickened; no cystidia; spores even, 4.5–6 × 3.5–4.5 μ, deep olive-buff to brown under the microscope, of the same color as the fructification.

Habitat: On soil and litter.

Type and specimens examined: Puerto Rico: Rio Piedras, Aug. 16, 1912. Collected by J. R. Johnston *4664*, comm. J. A. Stevenson (MBG *56589*). A second specimen was obtained on the Mycological Society Foray at Rochelle Hammock, Alachua Co., Florida, on litter.

Serpula hexagonoides (Burt) comb. nov.

Merulius hexagonoides Burt, Missouri Bot. Gard. Ann. **4**: 351. 1917.

Fructification resupinate, about 6 cm in diameter, effused, when fresh yellowish-green with a nearly white border, when dry papery, separable, drying between buffy-brown and Saccardo's umber, the margin thin and fimbriate; hymenium only very slightly elevated, of broad folds which become reticulately connected and form shallow, hexagonal pores about 1–2 to a mm, with folds of the largest pores nearly obliterated; in structure 1000 μ thick, with the broad folds extending 100–150 μ more, composed throughout of thin-walled, non-incrusted, slightly colored, occasionally nodose-septate hyphae 4–5 μ in

diameter, somewhat loosely interwoven; no cystidia; spores concolorous with the hyphae, even, 5–7.5 × 4.5 μ, borne 4 to a basidium.

Habitat: On charred wood of *Sequoia sempervirens*.

Distribution: California: Marin Co.: Muir Woods National Monument; Humbolt Co.: Between Requa and Eureka, Northspur.

Type specimen examined: On charred hollow *Sequoia sempervirens*, Muir Woods, Marin Co., Calif., Feb. 26, 1911. R. A. Harper (NYBG, MBG *55042*).

Serpula crassa (Lloyd) comb. nov.

Merulius crassus Lloyd, Myc. Writ. **7**: 1362. July 1925.

Fructification pileate, 5 × 7 cm in diameter; when fresh fulvous olive-yellow, velvety in texture; up to 1 cm thick, brown; surface with a cortex, irregularly arranged, soft and even at the surface; all hyphae with clamps; hyphae hyaline to yellow, densely interwoven, basically parallel; hymenium orange-yellow when fresh; basidia tightly packed, 15–20 × 5–7 μ; spores yellow, smooth, apiculate, cylindric, 5–6 × 2.5–3 μ.

Habitat: On (probably) pine log denuded of bark.

Type and specimen examined: New Hampshire: Meredith. Collected by Ann Hibbard, Aug. 1924 (CGL *26987*).

The closest relative of this species is *S. eurocephala* which is mostly tropical in distribution and has broader spores.

Serpula fusca (Lloyd) comb. nov.

Merulius fuscus Lloyd, Myc. Writ. **7**: 1348, Mar. 1925.

Lloyd's description follows: "Resupinate, no distinct margin. When soaked merulioid but not typically a *Merulius*. Color when dried distinctly reddish, about vinaceous-brown of Ridgway. When soaked Prout's brown, losing all the red. Spores (teste Rodway) slightly pale yellow, smooth, oblong, 8–9 × 2."

The specimen has been dried and soaked up at least once, during which the spores apparently have been washed away. No spores were evident in several mounts. No sterile organs were observed. The specimen apparently is a good *Serpula* but spores should be seen in fresh material. The color change is interesting but fresh material should be seen.

Habitat: On bark.

Type and specimen examined: Tasmania, 500 ft. Collected by L. Rodway, Sept. 1919 (CGL *19875*).

In spite of a lack of spores in the specimen studied, this species is recognized. It has all the appearance of being a good *Serpula;* the spores mentioned above may have belonged to another fungus. It is hoped that additional material may be collected in this type locality or elsewhere so that the status of this species may be determined more accurately.

Serpula fuscescens (Bres.) comb. nov.

Merulius fuscescens Bres., Ann. Myc. **18**: 41. 1920.

Fructification resupinate, crustaceous, adnate, olive-fuscus; when dry, specimen dark brown, margin very narrow, hyphae yellow-brown, septate, clamped, 4–9 μ in diameter; basidia 20–25 × 5–7 μ, 4-spored; spores 4.5–5.5 × 3–3.5 μ, smooth, apiculate, yellow-brown, ovate.

Habitat: On rotten wood.

Type and specimen examined: Brazil: Bahia. Collected by Torrend (NFC).

The specimen on which this species was based is similar in appearance to *S. pinastri* although the spores place it nearer to *S. eurocephala*. Torrend noted the spores as slightly larger than given here and hyaline becoming "luteo-fulvous." This species is maintained as distinct until sufficient material is available to place it more accurately.

Serpula chlorina (Pat.) comb. nov.

Merulius chlorinus Pat., Soc. Myc. Fr. Bull. **24**: 5. 1908.

Fructification resupinate, 3 × 4 cm, thin, pores gyrose-plicate, margin up to 5 mm wide, pale yellow, folds starting very shallow behind the margin, when dry, olive yellow to dark olive in color; hyphae in context strongly gelatinous, less so in subhymenium, up to 7 μ in diameter in context, to 3 μ in subhymenium, with simple and medallion clamp connections; hyphae contorted in context, separating readily in sections or scratch mounts; basidia 4-spored, 24 × 4–5 μ, clamped at base, arranged in a dense palisade; spores (in poor condition), 3–4 μ in diameter or slightly ovate, 3 × 4 μ, broad-ovate to spherical, yellow-brown, smooth, apiculate; brown granular material incrusting the hymenial region, tissues hyaline.

Habitat: On under surface of an old polypore and on adjacent bark.

Type and specimen examined: New Caledonia, M. Le Rat 1907. Patouillard Herbarium in Farlow Herbarium.

This specimen differs sufficiently from *Serpula eurocephala* to be retained as a separate species. *S. eurocephala* does not have the highly gelatinized cell walls of this species and its spores are narrower.

SPECIES NOT YET STUDIED

MERULIUS PUIGGARII Speg., Bol. Acad. Nac. Cienc. Cordoba **23**: 414. 1919.

The original description of this species is: "Resupinato-effusus, suborbicularis, matrici laxiuscule adhaerens et facile separabilis, determinatus, membranaceo-gossypinulus, mollis, citrinus, ambitu latiuscule sterilis, centro fertilis luteus crasse gyroso-porosus, dissepimentis obtusis crassiusculis; sporae latiuscule elliptico-ovatae, laeves, saepius grosse 1-guttulatae, ferruginae." The author notes that the specimens are 20–40 mm in diameter, with a sterile margin 2–3 mm wide, pores 1–1.5 mm wide, and spores 4.5×3–$4\ \mu$.

The specimen on which this species was based was collected on sticks on the ground, Apiahy, Argentina, in April 1891.

The description suggests that the material looks like *Merulius vastator* but the hymenial morphology approaches *Serpula eurocephala.*

MERULIUS SORDIDUS Berk. & Curt. in Cooke, Grevillea **19**: 108. 1891.

The original description follows: "Sordidus, resupinato-reflexus, submembranaceous, margine sublibero; subtus sericeus, pallescens. Hymenio sordide-fusco, reticulato-poroso, plicis sinuibus, sicco vix conspicuis, sporis $7 \times 5\ \mu$, dilute fuscis. On wood. Venezuela."

Spore size alone would place this in *S. pinastri* although reference to type material is necessary for a final decision as to its affinities.

MERULIUS VERSIFORMIS Berk. & Br., Jour. Linn. Soc. **14**: 58. 1875.

The following notes and description are taken from the original publication of this species:

"Tenuis, primum pulverulentus graniformis ex ochraceo rufus, demum gelatinosus; hymenio vix poriformis.

"On dead wood. South Island, July 1868. (Ceylon)

"At first forming a thin ochraceous pulverulent statum which is scattered with granules altogether after the fashion of *Grandinia;* but the hymenium gradually changes color, and becomes of a gelatinous texture, with raised irregular processes, which hardly form pores."

From this description and notes it would seem that either we have a *Grandinia*-like representative in the Coniophoraceae, or this is a rather atypical specimen of *S. eurocephala* which has a resupinate as well as a pileate phase.

MERULIUS INFUNDIBULIFORMIS Cooke & Mass. in Cooke, Grevillea **16**: 73. 1888.

The following description and notes are from the original publication:

"Tremellosus, magnus (5–6 unc. diam.), stipitatus. Pileo profunde infundibuliformi, crasso, laevi, sicco ruguloso, margine obtuso crispato, stipite brevi, crasso (1 unc. long, 1 unc. crass.) sulcato-rugoso, deorsum discoideo-expanso, hymenio poroso, acie denticulato, poris superne elongatis, irregularibus, angulatis, subtubaeformibus, inferne abbreviatis, reticulatis, sporis profusis, ellipticis, aureofuscis $12 \times 8\,\mu$.

"Apparently on wood. Yarra (*Miss Campbell*).

"An extraordinary species, of an uniform dark-brown colour when dry, wholly tremelloid and gelatinous when living, becoming hard and horny when dried."

This species can be compared with Lloyd's *S. erecta* which has smaller spores and which is not tremelloid.

MERULIUS MELANOCERAS Mont. in Cazin, E., Notice sur les champignons qui croissent dans les galeries souterraines de l'establissement thermal de Bagneres-de-Luchon, Paris. P. 28. 1859.

DOUBTFUL AND EXCLUDED SPECIES

MERULIUS CARMICHAELIANUS Berk., Outlines, p. 256.

Type material, or material from Scotland, has not been seen.

In a specimen from C. Roumeguère, Fungi Gallici Exsiccati, No. *2803*, from Oise, France, 1883, at the NYBG, the insufficient material consisted of insect droppings. There was a vaguely merulioid pattern of arrangement. A specimen under this number from Cornell University is a poor specimen of *Merulius tremellosus* Schrad. ex Fr.

MERULIUS DEBRISICOLA Lloyd, Myc. Writ. **7**: 1315. Oct. 1924.

The type specimen was sent to Lloyd by James Mitchell from Christchurch, New Zealand (CGL *19967*). It was reported as occurring on debris-covered earth permeated by mycelium. The specimen consists of a brown mineral deposit on calcareous material arranged in a merulioid pattern. There is a multitude of minute, spore-like, yellow particles, 1.5–2 μ in diameter. No structure is evident. Thirty years after the species was published there is no evidence of the mycelium reported as permeating the substratum. It is possible the specimn merely represents some of the mineralization occurring in active volcanic areas. See also Cunningham's (**1950**) comments on this species.

GYROPHANA JANTHINOSPORA (Pat.) Pat., Cat. rais. pl. cel. Tunisie 53. 1897.

Gyrophora janthinospora Pat., Explor. Tun. Illustr. Bot. tab. 4, fig. 1. 1894.

Coniophora janthinospora (Pat.) Sacc. & Trott. in Sacc., Syll. Fung. **21**: 412. 1912.

The type specimen of this species found in the Patouillard herbarium at the Farlow Herbarium was found on oak at El Feidja, Tunis, Jan. 1893. This specimen is not a *Serpula* but a hypochnoid species with hyaline, smooth, thin-walled spores, which Saccardo and Trotter considered a *Coniophora*.

SERPULA RUFA var. *pinicola* Karst., Hedw. **1896**: 45. 1896.

The following is the type description of this variety:

"Mycelium pelliculam tenuissimam, crustaceo-adustam, albam sistens. Hymenium carnoso-molle, aequiliter porosum, carneo-fulvum.

"In ligno pini in regione Mustialensi, m. Sept."

Type seen: "ad Pinum, Salois, Finland, Coll. P. A. Karsten, Sept. 1881."

Through the courtesy of J. L. Lowe, a portion of the type was seen. The specimen was sterile but the structure indicated that the specimen is a member of *Merulius sensu stricto*.

MERULIPORIA Murr., Mycologia **34**: 596. 1942.

With the characteristics of the species.

MERULIPORIA INCRASSATA (Berk. & Curt.) Murr., Mycologia **34**: 596. 1942.

Merulius incrassatus Berk. & Curt. in Lond. Journ. Bot. **1**: 234. 1849.

Merulius spissus Berk., Grevillea **1**: 70. 1872.

Polyporus pineus Peck, N. Y. State Mus. Rept. **41**: 78. 1888.

Poria pinea (Pk.) Sacc., Syll. Fung. **9**: 194. 1891.

Poria atrosporia Ames, Bot. Gaz. **55**: 399. 1913.

Serpula incrassata (Berk. & Curt.) Donk, Bot. Gard. Buitenzorg Bull. III. **17**: 474. 1948.

Fructification resupinate, annual, 1–12 mm thick, becoming effused up to 10–20 cm or more long; context separable from the substratum, whitish to cream to tan or light wood brown in color, formed of rather

loosely interwoven to parallel-arranged, generative, hyaline hyphae, 2.5–5 μ in diameter, some staining red in phloxine; hyphae in age with yellowish coloring material on the surface, more or less parallel with the substratum, branching irregularly, with rare clamp-connections; subiculum papery, very thin, peeling from the tubes, whitish-grey; tubes trametoid, regular, greyish-brown to blackish, 2–4 per mm, 0.1–1–10 mm deep, sometimes at first white; tubes round, distinctly poroid in section but at times merulioid in appearance, no hymenium on edges of dissepiments, not irpiciform nor lacerate; hymenium simple, composed exclusively of basidia; basidia 20–25 × 5–6 μ, 4-spored; spores greenish to olive-brown or dark brown, walls 0.7–1 μ thick, ovate, smooth, apiculate, somewhat flattened on one side, 9–12 × 5–7 μ; in phloxine mounts spores brown with brown walls and red straining contents; in lacto-phenol cotton-blue mounts spores blue with no colored walls nor contents visible; in Melzer's reagent spores brown with faint but well-marked blue halo especially in young spores. Spores evidently germinating readily in the tubes, young hyphae, apparently from the spores, being present in mounts made from the tubes, hyaline, 2.5–4.5 μ in diameter, with clamp-connections at the septa; cystidia, setae and hyphal pegs not seen. Rhizomorphs 3–10 mm in diameter, compressed, oval or round, extending from a source of water supply for great distances to the white, papery mycelial fans which cover large areas and which, in favorable places, terminate in the fructification.

Habitat and hosts: Rarely on decaying wood in the forest, more commonly on structural timbers, flooring and other wood in buildings as well as on railroad ties and on lumber in lumber yards. The following trees are host to the fungus in specimens examined: "gum wood," ?*Libocedrus decurrens, P. palustris, Pinus* spp., *Pseudotsuga taxifolia, Sequoia sempervirens,* and *Taxodium distichum.* The following hosts are added from Baxter's (**1940**) account: *Pinus ponderosa* and *Quercus borealis* var. *maxima.*

Specimens examined from: Ontario (2); Alabama (1), California (8), District of Columbia (1), Florida (10), Idaho (1), Louisiana (1), Mississippi (1), New York (2), Oregon (10), South Carolina (5), Tennessee (2), Virginia (1), Washington (1). In addition Baxter (**1940**) reports its occurrence in the following states: Georgia, Illinois, Kentucky, Michigan, Nebraska, Oklahoma, Pennsylvania and Texas.

Type specimens examined:

Merulius incrassatus Berk. & Curt.: Society Hill, South Carolina, M. A. Curtis *1504* (MBG *169822,* Curtis Herb. in Farlow Herb., NYBG). The specimen at MBG was obtained by Burt from Kew.

Merulius spissus Berk.: Obtained by Burt from Kew. This was an unnumbered specimen from Curtis marked "Car. inf." (MBG *169823*).

Polyporus pineus Pk.: Selkirk, New York. C. H. Peck, Aug. (LOO, NYBGL, NYS).

Poria atrosporia Ames: From structural timber in building, Auburn, Ala., Winter 1912–13. Coll. F. A. Wolf (CU).

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A NEW SPECIES OF PHACIDIELLA CAUSING THE SO-CALLED PHOMOPSIS DISEASE OF CONIFERS

GLENN GARDNER HAHN [1]

(WITH 2 FIGURES)

In 1920 Wilson (**12**) reported the Phomopsis disease of exotic Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco [2] and other conifers in Great Britain. He described the fungus *Phomopsis pseudotsugae* (FIG. 1, D) as the attributed cause.

Since that time considerable foreign literature has accumulated concerning the disease and the related organisms involved. In a paper dealing with *Phomopsis* on conifers, the author (**4**) indicated that *P. pseudotsugae,* which did not produce the characteristic β-type spores, could not be regarded as typical *Phomopsis* Sacc. Moreover, he showed that the forest-tree pathogen did not belong in the life history of a *Diaporthe* as Wilson (**13**) had stated. Until their respective perfect stages had been discovered, the writer preferred to retain *P. pseudotsugae* together with four other atypical species (**4**) in the genus *Phomopsis.*

One of the atypical Phomopses was the species described by Sydow as *Phomopsis strobi* (**11**) on eastern white pine (*Pinus strobus* L.) from Maine material collected originally by Dr. J. R. Weir. It occurred as a secondary fungus in a canker caused by *Cronartium ribicola* A. Fisch. *P. strobi* showed a very close morphological relationship with the foreign Douglas-fir canker and dieback parasite, which at that time was not known to occur in the United States (**16**). The author did not have the opportunity to study fresh material of the American *Phomopsis* in Britain. Accordingly, upon his return to the United States he continued its investigation on native pine. The cultural identity of *P. strobi* with the older species, *P. pseudotsugae,* was reported subsequently (**5**).

[1] Pathologist, Forest Insect and Disease Laboratory, Northeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, New Haven, Conn.

[2] Authorities for native conifer species are from E. L. Little, Jr., Check List of Native and Naturalized Trees of the U. S., Agriculture Handbook No. 41, 1953; those for exotics are from A. Rehder, Manual of Cultivated Trees and Shrubs, 2nd ed., 1940.

Further knowledge concerning the identity of *Phomopsis pseudotsugae* was contributed by Robak (**10**) in Norway. He demonstrated with pure cultures that the European wood-staining fungus, *Discula pinicola* (Naum.) Petr. (*Ligniella pinicola* Naum.) of Scotch pine and Norway spruce logs (**7**), is identical with the Douglas-fir parasite.

Research by the writer in the United States has indicated that *Phomopsis pseudotsugae,* besides being identical with *P. strobi* on cankered white pine, is also present in the Northeast as an occasional parasite on cankered branches of planted Douglas-fir, blue or Colorado form, in Rhode Island. It was not demonstrated, however, on similar Douglas-fir cankers such as those attributed to *P. lokoyae* Hahn (**5**), occurring in native stands on the Pacific Coast.

The perfect stage of the Wilson pathogen was discovered eventually in Maine. Immature ascocarps associated with sporulating pycnidia in the same stromata were first found in an elongate, nongirdling, basal canker of a mechanically-injured, living, white-pine sapling at Bar Harbor (FIG. 1, A). Further search on the site where the Weir-Sydow type of *Phomopsis strobi* has been collected disclosed mature material of this ascomycete (FIG. 1, C). A taxonomical investigation finally indicated that it belonged to the monotypic genus *Phacidiella* Poteb. Its type, *Phacidiella discolor* (Mout. et Sacc.) Poteb., is a European pathogen on apple and pear trees (**9**) not known to occur in the United States.

The description of the life history of the new species of *Phacidiella*[3] follows. Unpublished cultural data are also given regarding its imperfect or *Phacidiopycnis* Poteb. stage (**9**) previously described as a *Phomopsis.* The new combination with synonomy is cited. A brief taxonomical discussion concerning the little-known genus *Phacidiella* concludes the paper.

Phacidiella coniferarum sp. nov.[4]

Apothecia saepe cum loculis pycnidicis consociata in stromatibus innata; stromata infra peridermium evoluta, sed non cum eo concreta, areis ascomaticis singulis vel pluribus erumpentibus et in colonias aggregatis; ascomata discoidea, atra, carbonacea, 0.25–1.0 mm in diam., primum strato pulverulento olivaceo stromatico tecta, hoc strato deinde in lobis irregularibus soluto, demum delacerato et hymenium

[3] Inasmuch as *Phacidiella, Phacidiopycnis,* and *Phomopsis* all begin with the same letter, the abbreviation "*Ph.*" has been used for the first named and "*P.*" for the other two. Where the latter abbreviation is employed in the text, it occurs in a manner that makes it quite clear which of the genera *Phacidiopycnis* or *Phomopsis* is intended.

[4] The writer expresses his appreciation to Miss Edith K. Cash for the Latin description.

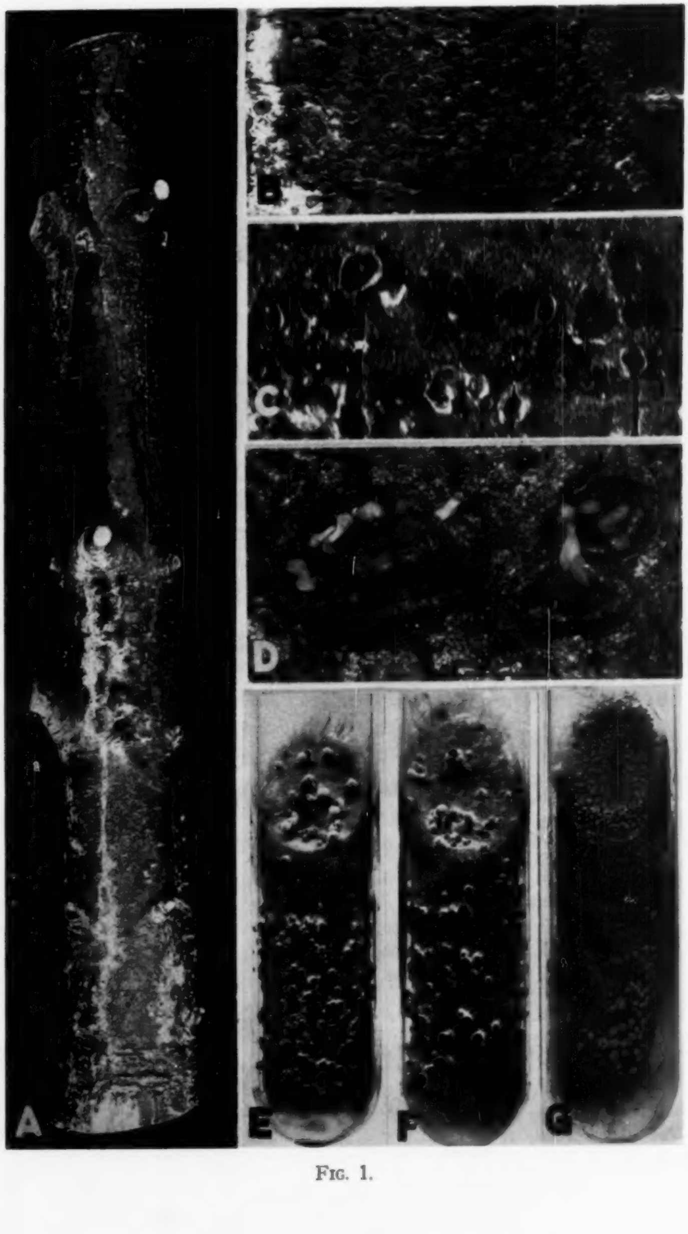

FIG. 1.

obscuratum detegente; asci cylindrico-clavati, longipedicellati, tenue tunicati, octospori, 80–135 × 8–12 μ; ascosporae irregulariter uniseriatae, continuae, interdum 1–2-septatae, hyalinae, guttulatae, ellipticae usque elliptico-fusiformes, apicibus obtusis vel subacutis, 10–18.8 × 2.8–6 μ, in ascis gemmantes et sporas secondarias breves, ellipticas bacillaresve, continuas, hyalinas, 3.4–4.8 × 1.0–1.6 μ gerentes; paraphyses numerosissimae, filamentosae, septatae, ad apices subinflatae, simplices vel interdum apices versus ramosae, ascos superantes, viridulae, epithecium pallide olivaceum efformantes; hypothecium tenuis; hyphae intra excipulum obscurum olivaceum pseudoparenchymaticum microsporas eis in ascis similes, ad isthmos tenues e cellulis hyphalibus oriundas gerentes.

Apothecia, frequently associated with pycnidial locules, innate in stromata developing under but not concrete with the periderm, one or more ascocarpic areas in individual stromata which become erumpent and occur in colonies on discolored areas of the trunk or branch; ascocarps discoid, black, carbonous, 0.25–1.0 mm in diam., at first covered by a pulverulent, olivaceous, stromatic layer which becomes losened in irregular lobes above the sporulating tissue and torn away finally; at maturity darkened hymenium fully exposed; asci cylindric-club shaped, elongate-stalked, thin-walled, 8-spored, 80–135 × 8–12 μ; ascospores irregularly uniseriate, continuous, occasionally uni- or biseptate, hyaline, guttulate, elliptic or elliptic-fusiform, extremities obtuse or subacute, 10–18.8 × 2.8–6 μ, producing bud spores in the ascus, short, elliptic or rod-shaped, continuous, hyaline, 3.4–4.8 × 1.0–1.6 μ; paraphyses exceedingly numerous, filamentous, septate, tips slightly swollen, simple or occasionally branched near the tip, outranking the asci, in mass greenish, tips uniting and forming a pale olivaceous epithecium; hypothecium shallow; free, vertical, unbranched hyphae within the dark, pseudoparenchymatous excipulum producing microspores comparable in size and shape to those in the asci, spores formed singly from individual hyphal cells on fine isthmi.

HABITAT: On living and dead trunks and branches of *Pinus strobus* in North America (Maine), August 1931 to May 1935. Type speci-

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FIG. 1. *Phacidiella coniferarum*. A. Elongate, non-girdling, basal canker of mechanically injured *Pinus strobus* sapling infected with immature *P. coniferarum* and its imperfect stage, *Phacidiopycnis pseudotsugae*, ⅓ natural size. B. Portion of colony in A, enlarged × 2½. C. Mature apothecia associated with imperfect stage, × 6½. D. Spore tendrils exuding from pycnidia of *P. pseudotsugae* on Douglas-fir bark in Great Britain, × 24. E, F, G. Comparable monospore cultures on synthetic malt agar: E. Isolate of *Phacidiopycnis* stage from type on white pine; F. Isolate of *Phacidiella* stage from type; G. Isolate of *Phacidiopycnis* stage from pine received from Birch (2) in New Zealand. E and F represent the stromatiferous-type culture; G, the very uncommon pycnidiferous type, natural size.

men FP *64031* [5] collected at Gerrish Island, Kittery Point, Maine, April 1934; in National Fungus Collections, Beltsville, Maryland.

Pycnidial stage:

Phacidiopycnis pseudotsugae (M. Wils.) comb. nov. (FIG. 1, D)

Phomopsis pseudotsugae M. Wils., Trans. Bot. Soc. Edinb. **28**: 47. 1920.

Phomopsis strobi Syd., Ann. Myc. **20**: 204. 1922.

Ligniella pinicola Naum., Novelties of the Local Mycoflora, p. 6. Leningrad, 1926.

Discula pinicola (Naum.) Petr., Svenska Skogsvårdsför. Tidskr. **25**: 209. 1927.

Discula pinicola var. *mammosa* Lager., Lundberg & Melin, Svenska Skogsvårdsför. Tidskr. **25**: 211. 1927.

HABITAT: In the northeastern United States, saprophytic or parasitic on: *Abies balsamea* (L.) Mill., *Larix decidua* Mill., *L. leptolepis* (Sieb. & Zucc.) Gord., *Pinus strobus* L., and introduced *Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco.

In Western Europe (**4**, **7**, **10**, **13**, **14**, **16**) saprophytic or parasitic on: *Abies alba* Mill. in Great Britain and Italy; *A. procera* Rehd. in Norway; *Cedrus atlantica* Manetti, *C. deodara* (Roxb.) Loud., *C. libani* Loud. in Great Britain; *Larix decidua, L. leptolepis, L. sibirica* Ledeb. in Germany, Great Britain, Holland, and Norway; *Picea abies* (L.) Karst. in Norway and Sweden; *Pinus mugo* Turra., *P. strobus* in Denmark; and *P. contorta* Dougl., *P. sylvestris* L. in Sweden; *Pseudotsuga menziesii* (Mirb.) Franco in Denmark, France, Germany, Great Britain, Holland, Ireland, Norway, and Sweden; *P. menziesii* var. *glauca* in Great Britain and Sweden; *Sequoia gigantea* (Lindl.) Decne. and *Tsuga heterophylla* (Raf.) Sarg. in Great Britain.

In Russia, near Leningrad (**8**), saprophytic on *Pinus sylvestris*.

In New Zealand (**2**), saprophytic on a number of conifers (species not reported) and parasitic on exotic *Pinus canariensis* C. Smith, *P. muricata* D. Don, and *P. radiata* D. Don.

Collections of *Phacidiopycnis pseudotsugae* from Europe and the United States have been deposited in the National Fungus Collections, Beltsville, Maryland.

[5] Collection number in the specimen file of the former Division of Forest Pathology, U. S. Dept. of Agriculture.

CULTURE STUDIES

Cultures derived from ascospores were identical with those obtained from spores of the associated imperfect stage (FIG. 1, E, F). The perfect stage, as in the New Zealand experiments (**2**), was not produced in culture. Culture characters of foreign isolates of *Phacidiopycnis pseudotsugae* obtained from fruiting bodies or host tissue agree with those of pure isolates of the imperfect stage from the Northeast. Isolates in this country were obtained from native white pine and balsam fir as well as from introduced Colorado Douglas-fir and European and Japanese larch.

Descriptions of the cultural characters of *Phacidiopycnis pseudotsugae* have already been published by several investigators; cultures of the species from exotic Douglas-fir in Great Britain, designated as *Phomopsis pseudotsugae,* were described by the writer (**4**); those of the blue-stain fungus *Discula pinicola* from pine and spruce logs in Sweden by Lagerberg, Lundberg, and Melin (**7**); and those of the pathogen *P. strobi* on exotic pines in New Zealand by Birch (**2**). The description given by the Swedish workers (**7**, f. 30–34) is the most detailed.

At least two distinct physiological strains have been demonstrated culturally in *Phacidiopycnis pseudotsugae*. These were first reported by Lagerberg *et al.* (**7**). A stromatiferous type, the one commonly encountered, was characterized by well-defined, pulvinate, sclerotium-like hyphal growths. They varied as to size, in some isolates the stromata attaining a diameter of 2 to 4 mm. Lagerberg *et al.* called them "stromatous formations" having a fine light greyish or brownish-grey capillose surface. Many of the stromata remained sterile; others, after an extended period of growth, produced sporulating pycnidial locules, the pycnidiospores exuding either as whitish or pale flesh-colored droplets or tendrils.

Birch's (**2**) isolations of *Phacidiopycnis pseudotsugae* (*Phomopsis strobi*) from diseased pines in New Zealand, which he designated in correspondence as "Form A," were likewise of the stromatiferous type. He reported that on the evidence of isolations made down under, growth characteristics did not vary sufficiently to indicate more than one strain. The stromatiferous type, moreover, was the one commonly produced by pure isolates (mostly monospore) made by the writer both abroad and in this country (FIG. 1, E, F). It was also the type that Robak (**10**) frequently isolated from spruce tissue and fruiting bodies of the species on introduced conifers in Norway.

Judging solely by culture characters, Lagerberg *et al.* (**7**) published

the stromatiferous type as the varietal form *"mammosa"* of the species *Discula pinicola*. They did this despite the fact that it was the form that they obtained most commonly in culture. At the same time they published a rarely occurring "profusely pycnidiferous main type," likewise based on cultural characters, as the species. They did not report in detail the cultural characters of the latter.

The essential difference between the two culture types would appear to consist in the ability of the one to produce a greater quantity of pycnidiospores in a much shorter time period. The experience of Birch, Robak, and the writer indicated that the pycnidiferous or non-stromatiferous type occurred only infrequently. It was characterized by an appressed growth with exceedingly scant aerial hyphae. This growth promptly gave rise to myriads of minute, blackish pycnidia from which pycnidiospore exudates occurred as whitish or pale flesh-colored droplets. With age, the spore exudates yellowed; in the presence of moisture they coalesced, giving the culture a slimy appearance (FIG. 1, G).

The pycnidiferous type of *Phacidiopycnis pseudotsugae* appeared only once during the writer's extensive culture study. He had it from a single spore isolation made from Douglas-fir in Great Britain. A culture of this same type isolated from *Abies alba* in Italy was sent him by Petri for study (**4**), as well as one from pine in New Zealand by Birch for the same purpose (FIG. 1, G). In correspondence, Birch stated that he had isolated the latter, which he called "Form B," just once and therefore made no mention of it in publication. Robak (**10**) also sent the writer a culture of the infrequently occurring pycnidiferous type taken from tissue of Norway spruce, No. *30*-I, for study and comment. Monopycnidiospore isolates of both Birch's Form B, and Robak's No. *30*-I reproduced identical sporulating cultures.

The writer succeeded in demonstrating that the character of abundant and rapidly sporulating pycnidia was inherent in the physiological strain. Monospore isolates of Robak's pycnidiferous type, No. *30*-I, were used to inoculate branches of plantation stock of *Picea pungens* Engelm., *Pseudotsuga menziesii* var. *glauca,* and *Tsuga canadensis* (L.) Carr. in Connecticut. Reisolations of mycelium in the tissue of artificially induced cankers on all three hosts produced cultures identical with Robak's original isolate.

Robak (**10**) reported that when isolate No. *30*-I was paired in culture with stromatiferous-type isolates, hyphae of the two types did not intermingle: a distinct border persisted between the two. On the other hand, the hyphae of paired stromatiferous-type isolates did intermingle. Somewhat similar pairing experiments were performed by the writer,

using Robak's No. *30*-I for the purpose of possibly obtaining the perfect stage in malt extract agar plates. As in the Robak tests, he observed that hyphae of the two distinct culture types did not intermingle. In fact, growth of stromatiferous-type isolates was greatly retarded in the presence of a much more extensive development of No. *30*-I. In plates containing paired isolates of the stromatiferous type, advancing hyphae did intermingle and none was retarded in growth.

Under ordinary laboratory conditions it has been the writer's experience that stock cultures of *Phomopsis* become solely vegetative and cease to sporulate. On the other hand those of *Phacidiella-Phacidiopycnis,* kept similarly, persisted in producing pycnidiospores even for more than 20 years if transferred regularly on malt extract or synthetic malt agars. When cultured on potato dextrose agar the medium invariably became decolorized.

Young hyphae of freshly isolated *Phacidiopycnis pseudotsugae* were filled with a homogeneous granular cytoplasm that extended regularly throughout to the growing tips. Among the normal hyphae that gave rise to stromata containing pycnidia, there occurred mycelial strands exhibiting a peculiar feature: the walls of these abnormal hyphae became irregularly thickened toward the lumen, which became correspondingly compressed, *i.e.,* thin and distended in some cells. They also produced abbreviated unicellular branches in which the cytoplasm appeared to have been excluded toward the swollen distal end (FIG. 2, D).

This peculiarity of the mycelium was observed on various agars, being especially clear in fresh colonies derived from germinated pycnidiospores on synthetic malt agar. The hyphal phenomenon, which apparently is rare among fungi, was also recorded by Potebnia (**9**, Pl. III, f. 12) for the type of *Phacidiella.* Brook (**3**), who corroborated these observations, likewise noted the wall thickening, a feature exhibited by all his isolations of *Phacidiella discolor,* particularly on prune agar.

SPORE STUDIES

The genus *Phacidiella,* as represented by the two species now known to belong to it, is exceedingly prolific as regards different spore types. Those produced by both stages of *Phacidiella coniferarum* germinated readily within 24 hours at room temperature. Only the *Phacidiopycnis* stage appeared in culture. In nature, it produced spores in great abundance. They averaged $6.7 \times 2.6\,\mu$ (**4**) in size.

Even smaller pycnidiospores borne on short delicate sporophores were encountered occasionally in cultures of *Phacidiopycnis pseudotsugae.* They measured $2.2–4.2 \times 1–2\,\mu$ and were not observed in na-

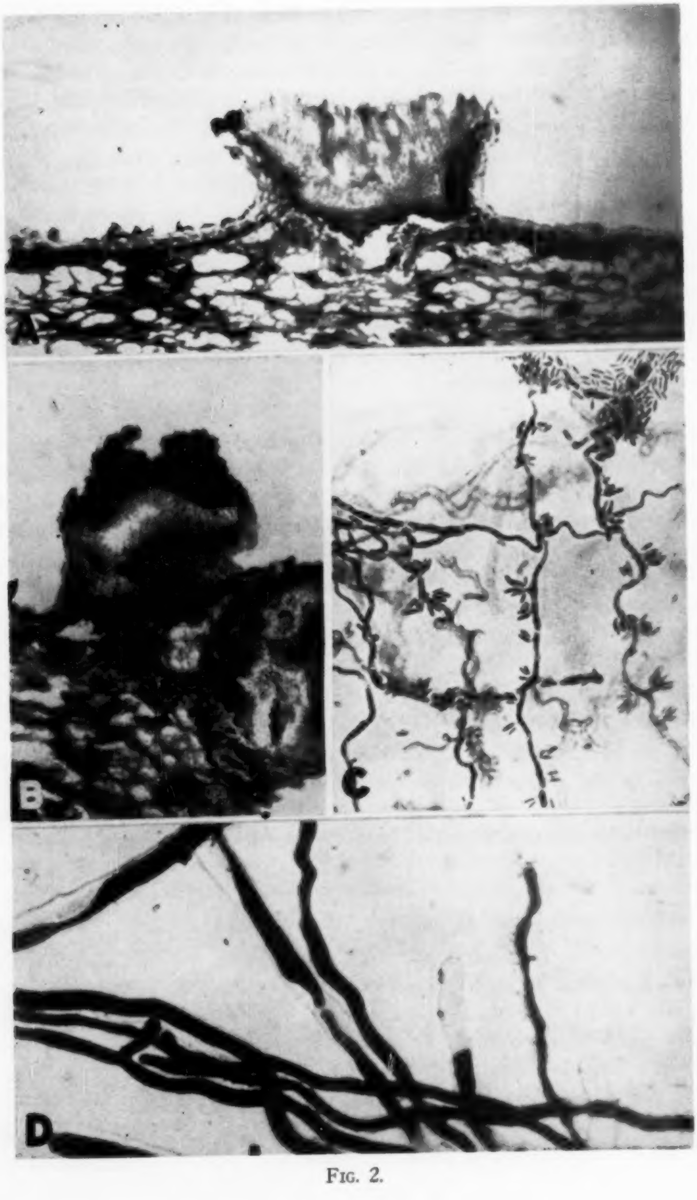

FIG. 2.

ture although very probably they do occur. It is very likely that Naumov (**8**) observed micropycnidiospores in nature, for in his original description of *Ligniella pinicola* he recorded pycnidiospores measuring 3.3–4.1 × 1.7 μ. However, when Lagerberg *et al.* (**7**) studied Russian collections of the Naumov species on Scotch pine, they recorded pycnidiospores of larger size, averaging 6.5 × 2.5 μ, a measurement closely approximating those reported for pycnidiospores of *P. pseudotsugae* as stated above and also by Wilson (**13**, **14**), Sydow (**11**), and Birch (**2**). In *P. malorum*, Potebnia (**9**) also recorded the presence of both macro- and micropycnidiospores occurring naturally. Brooks (**3**), however, did not find the latter in nature in England and he reported their occurrence in culture as irregular.

Phacidiella coniferarum produced germinable bud spores from its ascospores and from free vertical hyphae occurring within the exciple at the periphery of the ascocarpic hymenium. Similar bud spores were produced also by the larger conidia of the imperfect stage.

In addition, bud spores of another type were observed. They were narrow, elongate, with obtuse extremities, measuring 4–8 × 1–2.2 μ. They formed in culture soon after germination from the wall of the germinated pycnidiospore as well as from anywhere along those of the germ hyphae. Attachment was by an exceedingly fine connection and they occurred singly or were iterated in small groups from a delicate protuberance (FIG. 2, C). Mycelium budding profusely on both malt extract and potato dextrose agars was reminiscent of the growth of *Pullularia pullulans* (deBary) Berk. Non-budding hyphae grew out ultimately from the sporulating matrix which in due course produced stromata of varying size containing pycnidial locules. Budding mycelium was a persistent reproductive character in the species.

An isolate originating from a single ascospore, maintained in culture for at least a decade, not only continued to produce pycnidiospores but also hyphal bud spores. The latter were observed both on aerial mycelium and the appressed hyphae of the culture. None of the foreign investigators of *Phacidiopycnis pseudotsugae* in culture mentioned this commonly occurring reproductive process. Lagerberg *et al.* (**7**) did describe narrow, elongate, free spores in their cultures, measuring 6.5–9.3 × 2.3–2.8 μ, of unknown origin. There is the likelihood that

FIG. 2. *Phacidiella coniferarum*. A. Erumpent mature apothecium, × 80. B. Erumpent immature ascocarp with covering layer of stromatic tissue; associated with sporulating pycnidial locules, × 80. C. Budding mycelium of *Phacidiopycnis* stage on synthetic malt agar, × 300. D. Abnormal hyphae showing thickening of wall toward the lumen and hyphal tips in which cytoplasm has been excluded, × 880.

they were concerned with hyphal bud spores which occurred without question in culture studies of *Phacidiella discolor* described by Potebnia (**9**) and Brooks (**3**).

DISSIMILARITY WITH PHACIDIELLA DISCOLOR

The perfect and imperfect stages of *Phacidiella discolor* and *Ph. coniferarum* have many features in common, *e.g.*, the previously described phenomenon of certain hyphae possessing walls irregularly thickened toward the lumen (FIG. 2, D). Morphological differences, however, separate the two species. The ascospores of *Ph. coniferarum* are somewhat shorter and much narrower than those of the *Ph. discolor*. Potebnia (**9**) described the latter as measuring 17–22 × 8–10 μ and von Arx and Mueller (**1**) as 15–23 × 8–11 μ. Moreover, the asci of *Phacidiella discolor* are larger. According to Potebnia they measure 120–140 × 15–18 μ, and according to von Arx and Mueller (**1**) 150–220 × 15–18 μ. Occasionally ascospores of the conifer *Phacidiella* become uni- or biseptate. The foregoing workers did not mention similar septation in *Ph. discolor*. In addition, the Potebnia species is further distinguished by a reddish-violet epithecium, a distinctive diagnostic character.

The commonly occurring pycnidiospores of the *Phacidiopycnis* stage of *Phacidiella coniferarum*, averaging, as previously stated, 6.7 × 2.6 μ, are much smaller than the macropycnidiospores of *Ph. discolor*. The latter are cited by Potebnia (**9**) as measuring 10–12 × 8 μ and by Brooks (**3**) as 9–13 × 6–9 μ.

Culturally the two species appear to be dissimilar. This statement is made, however, on the basis of a comparison with a single culture of *Phacidiella discolor* on potato dextrose and malt extract agars. The isolate was obtained from the Centraalbureau voor Schimmelcultures, Baarn, Holland, and was isolated not from either an apple or pear tree canker but from a rotted pear, Doyeené de Comice. It produced an appressed growth with scanty aerial mycelium as Potebnia (**9**) had described. With age the substratum beneath the colony became a brownish-black, and abundant blackish glabrous stromata of varying size were distributed over the surface. Yellowish spore masses exuding from these stromata gave the colony a slimy appearance.

The *Phacidiopycnis* stage of *Phacidiella coniferarum* has a much wider geographical distribution and host range than that of the imperfect stage of the European *Ph. discolor* on apple and pear trees. Although the association of perfect and imperfect stages of *Ph. coniferarum* is known only on pine in the Northeast, geographically its *Phacidiopycnis*

stage, as previously indicated, is distributed widely and on a diversity of conifer hosts. Apparently it is able to perpetuate itself solely in the asexual stage, particularly as a pathogen on exotics in different parts of the world.

TAXONOMIC DISCUSSION

The taxonomy of *Phacidiella* Poteb. was discussed by its author at the time of publication of the description of the new genus. Its monotype, *Phacidiella discolor,* was the species originally designated as *Phacidium discolor* Mout. & Sacc. upon whose description that of Potebnia in 1912 was based. He regarded the fungus as related to the Phacidiaceae; but it was not a species of *Phacidium* Fr. as originally indicated, for its apothecia were not united with the host tissue. Hence Potebnia placed it in the sub-family Pseudophacidieae, wherein he commented Rehm had placed the genera *Pseudophacidium* Karst. and *Cryptomyces* Grev. (**9**).

Before the writer became aware of the close relationship between his new species, *Phacidiella coniferarum* and *Ph. discolor,* he considered placing the former in *Pseudophacidium.* Because of the controversy concerning the taxonomy of that genus, he undertook a first-hand study of authentic material of *Pseudophacidium ledi* (A. & S.) Karst. from the Karsten herbarium, which he obtained on loan through the courtesy of the Botanical Museum, University of Helsingfors. The investigation clearly demonstrated that the Finnish collection exhibited characters identical with those described by Karsten for *Pseudophacidium;* they were quite distinct from those shown by the writer's phacidiaceous fungus on white pine.

The concepts of genera in the Phacidiales and their relationships are so conflicting that it is difficult to get a clear-cut idea concerning them from the literature. Needless to say, *Phacidiella* has been variously considered taxonomically by different mycologists, as evidenced by the divergent opinions reported by von Arx and Mueller (**1**). These authors are in disagreement with von Höhnel, who stated that *Phacidiella* belongs in the Stictidaceae, a heterogeneous family which they believe should be discarded. Nannfeldt's conception of *Phacidiella* as Myriangiaceous they regard as error without proof. They also take note of the fact that Petrak adhered to von Höhnel's diagnosis of *Phacidiella* without expressing any opinion of his own concerning it. Von Arx and Mueller conclude that *Phacidiella* is allied to *Cryptomyces* and place it in the family Cryptomycetaceae. The only species discussed under *Phacidiella* is *Ph. discolor.*

Conflicting opinion also exists concerning the imperfect stages of the Phacidiales. Various genera have been reported as being connected with certain ascomycetous genera in the group, *i.e., Ceuthospora* with *Phacidium, Myxofusicoccum* with *Myxophacidiella, Melasmia* with *Rhytisma,* etc. Most connections have been based merely on association and how many have been actually proved is doubtful. In the case of the proven imperfect stage of *Phacidiella discolor,* Potebnia (**9**) created the new genus *Phacidiopycnis,* so-named because of its relationship to the Phacidiaceae, with the type, *Phacidiopycnis malorum.*

Von Arx and Mueller (**1**) recently published the pycnidial stage of *Phacidiella discolor* as *Discula pyri* (Fckl.) Hoehn. In this regard it is pertinent to note that Brooks (**3**), as the result of a study of *Phacidiopycnis malorum* in England, reported the investigation of a Kew Herbarium specimen of *Cytispora pyri* Fckl., the species upon which the *Discula* combination is based. He stated that it cannot possibly be identical with *P. malorum.* Certainly *Phacidiopycnis* is more appropriate than *Discula,* a melanconiaceous genus of questionable status.

In connection with *Phacidiopycnis malorum,* two fruit-rot organisms, *Fuckelia conspicua* El. & Em. Marchal and *Pyrenochaeta furfuracea* (Fr.) Rostr., were investigated by Brooks (**3**) and by Jørstad (**6**), respectively. Brooks stated that the *Fuckelia* was synonymous with the older *P. malorum.* Rostrup's species of *Pyrenochaeta* was regarded by Jørstad also as *Phacidiopycnis.* It was only after a careful consideration of allied genera in the difficult group of imperfect fungi (Sphaeropsidaceae-stromaceae-hyalosporeae) that Potebnia (**9**) decided finally to establish *Phacidiopycnis.* Brooks was of the opinion that for the time being *Phacidiopycnis* was the best name for the pycnidial stage of *Phacidiella.* At least it will serve its purpose until we come to a clearer understanding of the relationships of the imperfect genera involved.

U. S. DEPT. OF AGRICULTURE,
FOREST SERVICE,
NORTHEASTERN FOREST EXPERIMENT STATION,
FOREST INSECT AND DISEASE LABORATORY,
335 PROSPECT STREET,
NEW HAVEN, CONNECTICUT

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THE GENUS ACTINOMUCOR[1]

Chester R. Benjamin and C. W. Hesseltine

(with 7 figures)

Actinomucor, one of several monotypic genera of the family Mucoraceae, was originally described by Schostakowitsch (**17**) in 1898 from "Taubenmist" from Siberia. Schostakowitsch stated that the genus was closely related to *Mucor,* but differed in having branched stolons which gave rise to rhizoids and sporangiophores. He also stated that the genus was distinct from *Rhizopus* and *Absidia,* two other stoloniferous genera, because of the limited growth of its stolons and the different formation of its columellae and sporangiophores.

Our own observations are in accord with the findings of Schostakowitsch. *Actinomucor* differs from *Mucor* by the formation of rhizoids and stolons and by the mode of branching of the sporangiophores. In most other characteristics *Actinomucor* is quite similar to *Mucor.* As pointed out by Schostakowitsch, the genus resembles *Rhizopus* in having rhizoids, stolons and spherical sporangia. It differs from that genus, however, in the projection of whorls of short branches below the terminal sporangia of the sporangiophores. Also, it lacks the dark pigmentation of the striate sporangiospores which characterize many of the species of *Rhizopus.* Contrary to the case in *Absidia* and *Rhizopus* there is no apophysis present in *Actinomucor.*

This organism was again described as a new genus, called *Glomerula,* in 1903 by Bainier (**1**). By coincidence both Bainer and Schostakowitsch used the same specific epithet, *repens.* Lendner (**9**), in his system of classification, placed *Actinomucor* in the family Thamnidiaceae, but Naumov (**11**) and Zycha (**20**) considered it a member of the family Mucoraceae, as do the present authors. In our opinion the resemblance of *Actinomucor* to *Thamnidium* is a superficial one and not indicative of close relationship. *Actinomucor,* like *Rhizopus,* probably has evolved from an ancestor of some member of the *sphaerosporus*-section of *Mucor.*

[1] Contribution from the Northern Utilization Research Branch of the Agricultural Research Service, U. S. Department of Agriculture, Peoria, Illinois.

Actinomucor Schostakowitsch, Ber. Deut. Bot. Ges. **16**: 155, pl. IX, figs. 1–13. 1898.

Glomerula Bainier, Bull. Soc. Myc. France **19**: 154. 1903.

Mycelium branched; stolons and rhizoids present, both branched; sporangiophores typically, but not always, arising opposite rhizoids, branched, septate, often bearing below a terminal sporangium a whorl of short branches which are often thickened and which terminate in small sporangia; all sporangia spherical and many-spored; apophysis lacking; sporangiospores continuous, hyaline, and never striate; zygospores unknown; chlamydospores present or absent.

Type: *A. repens* Schost.

Actinomucor elegans (Eidam) comb. nov. FIGS. 1–7.

Mucor corymbosus Harz, Bull. Soc. Imp. Nat. Moscou **44**: 143. 1871. (See Hedwigia **11**: 136. 1872.) Not *Mucor corymbosus* Wallroth, 1833.

Rhizopus elegans Eidam, Jahres-Ber. Schles. Ges. für vaterl. Cultur **61**: 232. 1884.

Mucor harzii Berl. & De Ton., in Saccardo's Syll. Fung. **7**: 202. 1888.

Actinomucor repens Schost., Ber. Deut. Bot. Ges. **16**: 155. 1898.

Glomerula repens Bainier, Bull. Soc. Mycol. France **19**: 154. 1903.

Mucor glomerula Lendner, Les Mucorinées de la Suisse 69. 1908.

Mucor botryoides Lendner, Bull. Soc. Bot. Geneva **2**: 79. 1910.

Mucor repens (Bainier) Sacc. & Trott., Syll. Fung. **21**: 821. 1912.

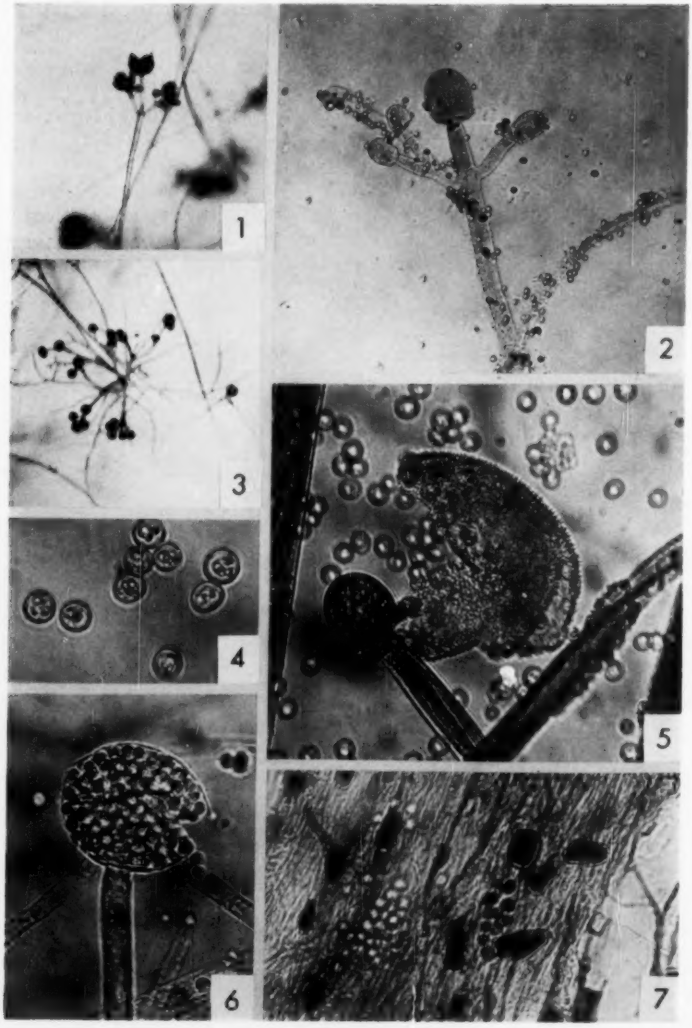
Mucor botryoides var. *minor* Jensen, Cornell Univ. Agr. Exp. Sta. Bull. **315**: 457. 1912.

Mucor cunninghamelloides Pispek, Acta Bot. (Zagreb) **4**: 89. 1929.

Actinomucor corymbosus (Harz) Naumov, Clés des Mucorinées 55. 1939.

Actinomucor corymbosus, forma *palaestina* Rayss, Palestine Jour. Bot., Jerusalem Ser. **3**: 162. 1946.

Colonies appearing cottony to cobwebby, over 1 cm in height, vigorously growing, white to Tilleul-Buff (Ridgway, Pl. XL (**15**)) in color, in age ranging from white to Deep Olive-Buff (R., Pl. XL) or Drab-Gray (R., Pl. XLVI) in color; colony reverse white, in age often becoming Pale Olive-Buff (R., Pl. XL), but never more deeply colored than Pale Orange-Yellow (R., Pl. III); odor slightly acrid, yeasty; stolons and rhizoids present, colorless; stolons branched, often septate, up to 25 μ in diameter; rhizoids repeatedly branched, well-developed, often septate, up to 25 μ in diameter; sporangiophores arising from the sub-



FIGS. 1–7. *Actinomucor elegans.* 1. Sporangiophore and sporangia of NRRL *1706* as observed in a petri dish, × 70. 2. Terminal portion of a sporangiophore, showing one method of branching and the columellae of terminal and secondary sporangia, NRRL *1706*, × 125. 3. Cluster of young sporangiophores attached by rhizoids to a petri dish cover, NRRL *1706*, × 70. 4. Sporangiospores of strain NRRL

strate mycelia, from aerial hyphae, and from stolons at points opposite to the rhizoids formed where the stolons touch the substrata and Petri dishes, variable in length, up to 30 μ in diameter, short and in clusters or longer and verticillately or racemosely branched, terminating in large sporangia, with cross-walls typically located above the origins of branches or whorls of branches; whorled branches sometimes re-branched, originating short distances below the terminal sporangia and bearing secondary sporangia subtended by cross-walls; sporangia spherical, buff-colored in reflected light, dark gray in transmitted light; terminal sporangia with deliquescent or persistent, smooth or spiny, walls, mostly less than 80 μ, but occasionally up to 120 μ in diameter; secondary sporangia with persistent spiny walls, many-spored, mostly 20–50 μ in diameter; columellae of the large sporangia elongate-oval to pyriform, hyaline to faintly colored, mostly $50–60 \times 30–40\ \mu$, but ranging up to $72 \times 48\ \mu$; columellae of the secondary sporangia globose to dorsiventrally-flattened, 12–30 μ in diameter; persistent sporangial walls usually splitting and recurling in an irregularly-stellate fashion; sporangiospores smooth to faintly-roughened, heavy-walled, singly hyaline, in mass gray-black, globose, mostly 6–8 μ in diameter; chlamydospores, when present, varying considerably in size and shape, occurring singly or in short chains; zygospores unknown.

TYPE: Since the original material upon which Harz based his species is probably no longer in existence, the authors propose Bainier's strain of *Glomerula repens*, NRRL *1706*, as a NEOTYPE.

The preceding description allows for the range of variation of the species and is based primarily on the following strains as observed on synthetic mucor agar (SMA): NRRL *1706*, NRRL *685*, NRRL *1403*, NRRL *1404*, NRRL *2227*, and NRRL *2551*. Media mentioned in this paper are the same as used in other studies on the Mucorales from this laboratory. More than 50 different strains were studied, including isolates from soil of Wisconsin, California, Brazil, Chile, Peru and Afghanistan. Other strains originated from air, fungi, germinating beans, dung, soya cheese, soya bean cake and hops. The type culture, NRRL *1706*, was secured by our laboratory in 1940 from Harvard University as their No. H-*37*, representing the type strain of Bainier's genus *Glomerula* which R. Thaxter had obtained directly from Bainier. Additional strains were received from culture collections at the University of Tokyo, the American Type Culture Collection, the Common-

685, × 690. 5. Portion of a broken sporangium, showing the very rough nature of the sporangial wall, NRRL *685*, × 340. 6. An almost intact sporangium, showing the enclosed spores and the smooth nature of the sporangial wall, NRRL *685*, × 340. 7. Chlamydospores of NRRL *2551* stained with cotton blue, × 340.

wealth Mycological Institute, the Institute for Fermentation, Osaka, Japan, and the Centraalbureau voor Schimmelcultures, Baarn, Holland. Space does not permit the acknowledgment of the many persons who contributed material or cultures for this study.

Actinomucor elegans can be readily recognized by its growth upon SMA and potato-dextrose-agar (PDA) because of the luxuriant development of almost-white aerial mycelia. Cultures upon aging become slightly brownish-colored, but never blackish. The colonies typically cover the surface of the media in Petri dishes and grow up to the lids. Using a dissecting microscope, one can readily see the sporangiophores arising opposite the rhizoids attached to the lid of the dish. Also characteristic are the distinct whorls of short branches w th sporangia which in some instances have broken open even though they had not been disturbed. Chlamydospore production, however, appears to be of no diagnostic value at all because of the wide variation among strains. NRRL *685* apparently produces none; NRRL *1706* produces a moderate number; NRRL *2551* produces them in abundance.

The nomenclature of *Actinomucor elegans* has been considerably confused in the literature. The organism was first recognizably reported in 1871 when Harz (**5**) described it as a new species, *Mucor corymbosus,* from moldy ergot. It was independently described as a new species of *Rhizopus, R. elegans,* by Eidam (**4**). Berlese and De Toni (**2**) noted that *Mucor corymbosus* Harz was a later homonym and renamed it *Mucor harzii.* Ten years later Schostakowitsch (**17**) erected his genus *Actinomucor,* based on a strain agreeing in description and measurements with the strains of Harz and Eidam. When Bainer (**1**) found his strain, like Schostakowitsch, he considered it representative of a new genus and named it *Glomerula repens.* Lendner (**9**) put the genus *Actinomucor* into the Thamnidiaceae, treated *Mucor corymbosus* Harz and *Rhizopus elegans* Eidam as valid species of those genera, and placed *Glomerula repens* Bainier in *Mucor* as *M. glomerula* (Bainier) Lendner. Two years later he (**10**) described another strain as *Mucor botryoides.* Reinhardt (**14**) recognized the fact that *Rhizopus elegans* Eidam, *Actinomucor repens* Schost., and *Mucor botryoides* Lendner were synonymous, but he retained Lendner's name for the organism. Zycha (**20**) retained the name *Actinomucor repens* Schost. and Naumov (**11**) made the new combination, *Actinomucor corymbosus* (Harz) Naumov.

Inasmuch as *Actinomucor* is distinct from both *Rhizopus* and *Mucor,* it is desirable that the genus be maintained, but since the only included species was described earlier by both Harz and Eidam, Schostakowitsch's

epithet "*repens*" must be replaced. Harz's name "*corymbosus*" is untenable because Harz's name for the organism is a later homonym of Wallroth's (**18**). The earliest valid specific epithet, then, is Eidam's "*elegans,*" and the proper combination is *A. elegans.*

Mucor botryoides var. *minor* Jensen was described in 1912 by Jensen (**7**) who isolated the organism from soil collected at Cornell University in 1910. Although his description differed somewhat from that of Lendner, the differences are not outside the normal limits of variation as observed in the present study. The varietal rank of Jensen's strain is, therefore, unnecessary, as is the case also regarding the *Actinomucor corymbosus,* forma *palaestina* Rayss described by Rayss (**13**) in 1946.

Of the many genera and species of the Mucorales thus far studied in our laboratory, growth upon Czapek's agar is nearly always very poor, resulting in scanty substrate-mycelial development and the production of very few sporangiophores. Since growth is barely detectable grossly, the colonies are uncolored. This poor-growth phenomenon is especially typical of species of *Mucor* and *Rhizopus.* An exception, however, is *Cunninghamella,* a genus believed to be far removed on the evolutionary scale from *Mucor, Rhizopus,* and *Actinomucor.* In *Actinomucor,* growth is often quite as good and sporulation as abundant on Czapek's agar as on SMA, PDA, or malt agar. Several strains, however, showed lesser amounts of growth and a very few, such as NRRL *2551,* showed a scanty amount.

It seemed desirable to study the utilization of some common nitrogen and carbohydrate sources by this fungus. Five representative cultures were selected. Two (NRRL *685* and NRRL *1706*) had been kept in pure culture for many years and three (NRRL *2551,* A-*6404,* and A-*6503*) were recent isolates.

Czapek's solution was used as a basal medium. For the carbohydrate-assimilation tests, other carbohydrates were substituted for sucrose at a 3% level, except for cellulose, which was added as strips of filter paper immersed in Czapek's solution in test tubes. With all other carbohydrates purified agar was added to the solution, and the cultures were grown in Petri dishes. Excepting starch, the carbon sources were filter-sterilized separately and added after the basal medium had been autoclaved. The pH of the medium was unadjusted.

In the case of the nitrogen sources, the same procedure was used except that different nitrogen sources were added at a level of 0.3% by weight. The carbon source used in the nitrogen tests was sucrose at a 3% by weight level.

TABLE I

UTILIZATION OF CARBOHYDRATE AND NITROGEN SOURCES BY ACTINOMUCOR ELEGANS

		Strain number				
		NRRL *685*	NRRL *1706*	NRRL *2551*	A-*6404*	A-*6503*
Carbohydrate Sources	Carbon-free control	−	−	−	−	−
	L-Xylose	+	+	+	+	+
	Glucose	+	+	+	+	+
	Sucrose	+	+	(−)	+	+
	Lactose	−	−	−	−	−
	Glycerol	(−)	(−)	(−)	(−)	(−)
	Starch	+	+	+	+	+
	Cellulose*	−	−	−	−	−
Nitrogen Sources	Nitrogen-free control	−	−	−**	−	−
	Potassium nitrate	+	+	+**	+	+
	Sodium nitrate	+	+	+**	+	+
	Ammonium sulfate	+	+	+**	+	+
	Urea	+	+	+**	+	+

* Cellulose as filter paper suspended in liquid medium.
** Glucose used as carbon source.
The symbols used are: − no utilization, + utilization, (−) slight or no utilization.

All tests were made with approximately 20 mls of media. Incubation was for 4 days at 25–26° C, except in the case of the cellulose test, in which incubation was for 5 days. Slight visible growth occurred in the controls, with which the growth of the test strains on the various compounds was compared. If the growth of a test strain was no better than that of the control, the strain was considered negative for that compound. Growth was judged on the basis of the quantity of mycelium produced, and the results are summarized in TABLE I. It can be concluded that strain differences exist and that all the tested strains utilize xylose, glucose and starch. They vary in the utilization of sucrose, utilize glycerol poorly, and do not use lactose or cellulose at all. All strains can utilize the tested nitrogen sources, if the carbon source is not a limiting factor. However, it was found in the original nitrogen assimilation experiment that strain NRRL *2551* failed to grow or grew very poorly on all of the tested nitrogen sources. Observation of the carbon assimilation test data showed that the strain did not utilize sucrose, which had been used for a carbon source in all of the nitrogen tests. Substitution of glucose for sucrose in the basal medium for the nitrogen tests of NRRL *2551* resulted in fair to good growth on all four nitrogen sources.

Le Clerg (**8**) reported some cultural data for two strains isolated from Colorado soil as "*Rhizopus elegans* Eidam" and "*Mucor glomerella* (Bainier) Lendner." One of his strains grew fairly well and the other quite well on Czapek's agar. He reported growth on gelatin, mannose, inulin, and peptone as well. Zach (**19**) indicated good growth by 4 strains (called *Mucor botryoides* Lendner) on sucrose, very poor growth on dextrin and galactose, and, in common with our experience, no growth on lactose.

Zygospores have been seen in all except three of the thirteen genera of the family Mucoraceae as delineated by Hesseltine (**6**). The exceptions are *Saksenaea, Pirella* and *Actinomucor.* The extreme rarity of isolation may explain the failure to find zygospores in the first two genera, but the case for *Actinomucor* cannot be explained so easily since it has been isolated by many investigators and can be found without a great deal of difficulty. In the present study it seemed probable that zygospores might be induced to form, since 55 strains were available. Zach (**19**) had earlier reported that one of his *Actinomucor* strains would start to form zygospores with *Absidia glauca* (+), but not with *A. glauca* (−). This response would indicate that *Actinomucor elegans* was heterothallic.

A great number of mating combinations were made on a variety of media and at several temperatures, with a uniform lack of zygospore production. In one experiment, 12 strains of *Actinomucor* were mated on PDA, malt, corn-steep, hay, Czapek's and Emerson's agars. The mated cultures were incubated at 20, 24, 28 and 32° C and were examined for zygospores after 7, 14 and 21 days. All matings were negative. It was obvious that 32° C was near the maximum temperature at which the organisms would grow, so that temperature was not used again. Many different strain combinations were made using additional types of media, including that used by Blakeslee *et al.* (**3**) in their hydridization studies, but all were negative. Further matings were attempted between heavy chlamydospore-producers, between light chlamydospore-producers, and between various combinations of the two, but again no zygospores were produced. We have no explanation for our failure to secure zygospores.

SUMMARY

On the basis of study of some 50 strains of *Actinomucor,* the genus is reevaluated and found still to be monotypic. The new combination *Actinomucor elegans* (Eidam) Benjamin & Hesseltine is made. Descriptions in English and the synonymy are given. The genus shares

a number of characteristics with *Mucor* and *Rhizopus*, but is taxonomically distinct. Some cultural characteristics are noted. Test strains utilized various carbon sources, but neither lactose nor cellulose. Common nitrogen sources were utilized. A great number of mating combinations on a variety of substrata failed to produce evidence of zygospore formation.

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NORTHERN UTILIZATION RESEARCH BRANCH,
U. S. DEPARTMENT OF AGRICULTURE,
PEORIA, ILLINOIS

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THE SPORES AND BASIDIA OF SIROBASIDIUM

R. J. Bandoni

(WITH 2 FIGURES)

The genus *Sirobasidium* was erected by Lagerheim and Patouillard (**1892**) to include two species, *S. albidum* and *S. sanguineum*, collected in the crater of Pululahua, Ecuador. In addition to having basidia borne in catenulate series, the genus was described as producing sessile fusiform basidiospores, the germination of which had not been observed. Three years later, Möller (**1895**) described a third species, *S. brefeldianum*, from Brazil. He was able to germinate the spores of his species, but it is clear from his discussion and figures that he misinterpreted the results. From the large number of spherical spores which he found in his cultures, Möller concluded that the fusiform spores typical of the genus were not completely mature when shed, "und gehen, währen sie durch die Luft fliegen, von der länglichen zur kugelrunden Gestalt über." Since then several mycologists have observed germination of spores of *S. sanguineum* and *S. brefeldianum* by budding or by germ tube. (Coker, **1920**; Olive, **1947**; Lowy, **1956**), and Martin (**1936**) reported germination by repetition of the spores of a specimen of *S. sanguineum* from Australia.

Recently, during examination of specimens of *Tremella* in the Lloyd Mycological Collections, it was found that the type specimen of *T. fusca* Lloyd (nec *T. fusca* DC.) is a *Sirobasidium*. In it, some of the fusiform spores retained in the gelatinous matrix had germinated by the production of short tubes tipped with sterigmata upon which were borne typical apiculate basidiospores (fig. 1, d, e). That this was not simply a case of germination by repetition is indicated by the fact that the apiculate spores differ conspicuously from the fusiform structures produced by the basidia, whereas the phrase "germination by repetition" implies the production of a ballistospore morphologically like the parent basidiospore, but usually somewhat smaller. Subsequent examination of specimens of *Sirobasidium* in the herbaria of the New York Botanical Garden and of the State University of Iowa revealed the presence of typical apiculate basidiospores in most collections.

Spores of a specimen of *Sirobasidium sanguineum*, collected and determined by B. Lowy (collected 5 miles south of Baton Rouge, Louisiana,

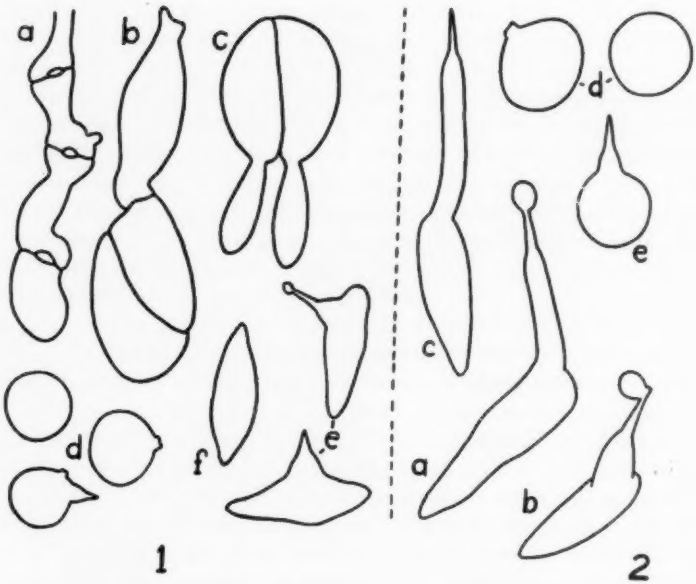
Nov. 17, 1955), were successfully germinated on July 20, 1956. A portion of one pustule of the fructification was examined microscopically and appeared to be in satisfactory condition. The remainder of the pustule was then soaked in water for about 10 minutes, placed on a microscope slide, and transferred to a moist chamber in which sufficient water had been placed to maintain high relative humidity. Small portions of the material were removed from time to time and examined microscopically. Eleven hours after soaking, large numbers of the fusiform spores were observed in various stages of germination through formation of tubular extensions of variable lengths tipped with sterigmata (FIG. 2, a, b) upon which were produced typical basidiospores. These were entirely different in form from the parent spores and were similar to those found in the fructifications of other specimens of *Sirobasidium*. Many of the spherical spores were found to be germinating by repetition and some by budding.

According to Martin (**1945**), catenulate basidia are found occasionally in both *Tulasnella* and *Gloeotulasnella*. He also suggested the possible homology between spores of *Sirobasidium* and epibasidia of other tremellaceous fungi. Certainly the so-called basidiospores of *Sirobasidium* which germinate terminally bear a striking resemblance to epibasidia of *Gloeotulasnella* as illustrated by Rogers (**1934**, figs. 12, 13, 15). Furthermore, the epibasidia of certain species of *Tulasnella* sometimes become detached from the hypobasidium before producing spores (Juel, **1897**; Martin, **1931**). It would seem obvious, from the structure and type of germination, that the fusiform structures are homologous with the epibasidia of other tremellaceous fungi. The points in favor of this interpretation are as follows:

(a) Their development does not differ from that of epibasidia in the *Tremellaceae*. Prior to the time when these structures are shed (FIG. 1, c), an individual basidium in *Sirobasidium* is morphologically indistinguishable from a *Tremella* basidium with epibasida.

(b) They are of the same form and as variable in length as the epibasidia of many tremellaceous fungi. The amount of variation in length noted in these structures was 11–30 μ in *S. sanguineum*, 16–39 μ in *S. brefeldianum*, and 15–31 μ in *S. albidum*. This range would not be excessive for tremellaceous epibasidia, but would be unusual for basidiospores.

(c) The spores which are produced upon their germination are unlike them in form and are abstricted from them in the same manner as basidiospores of other tremellaceous fungi.



All figures drawn with the aid of a camera lucida and reduced in reproduction to approximately $\times 1000$.

FIG. 1. ***Sirobasidium sanguineum,*** Lloyd coll. *4009,* Torrend, Brazil. a. Fertile hypha showing development of cells destined to become basidia. b. Two probasidia, one almost mature, the other just beginning to expand. c. Mature basidium before epibasidia have been shed. d. Basidiospores. e. Two epibasidia germinating by production of tubes tipped with sterigmata. f. Epibasidium.

FIG. 2. *S. sanguineum,* Lowy, Louisiana. a, b. Epibasidia germinating by the production of tubular lateral extensions. c. Epibasidium germinating terminally. d. Two basidiospores. e. Basidiospore germinating by repetition.

The relationship between the *Sirobasidiaceae* and *Tulasnellaceae,* as evidenced by basidial development, would appear to be a close one. Lagerheim and Patouillard pointed out the obvious similarity in morphology of the basidia of the *Sirobasidiaceae* and *Tremellaceae.* All of this points to an additional possibility which should be considered in discussions of the phylogeny of lower Basidiomycetes; namely: that both the tremellaceous and tulasnellaceous basidial forms may have evolved from an ancestral type possessing *Sirobasidium*-like basidia, the former through loss of the septa separating the epibasidia from the hypobasidium, and the latter through loss of the cruciate septation of the hypo-

basidium. As has already been stated, caducous epibasidia are sometimes found in species of *Tulasnella*. Therefore, the distinction between epibasidia which are retained on the hypobasidium, but separated from it by septa, and the type found in *Sirobasidium* would not appear to be great.

Observations made during the course of this investigation necessitate the following recharacterization of the genus *Sirobasidium*.

SIROBASIDIUM Lagerh. & Pat., Jour. de Bot. **16**: 465. 1892.

Fructifications gelatinous, tuberculate to variously lobed or foliaceous; hymenium amphigenous; basidia arranged in simple or branched chains, separated from one another by clamp connections, maturing basipetally from cells which are cut off acropetally, varying in shape from spherical to fusiform and becoming longitudinally (cruciate) to transversely 1–3-septate; epibasidia variable in length, more or less fusiform, deciduous, producing short tubes tipped with sterigmata, or the sterigmata arising directly from the epibasidial wall; basidiospores apiculate, abstricted in the usual manner, germinating by repetition or by budding.

The type specimen of *Tremella fusca* Lloyd (**1917**) agrees in most respects with the original description of *Sirobasidium sanguineum* Lagerh. & Pat. The measurements for the detached epibasidia are somewhat smaller than those cited in the original description, but within those given for this species by Olive (**1946**). In this specimen, only the terminal cell of most of the chains appears to have developed, but a few series of 2 or 3 catenulate basidia were observed. The basidiospores are circular in outline in one view, ellipsoid with the apiculus projecting at right angles to the long axis in the other, and measure $7–9 \times 5.5–8\,\mu$. Basidiospores of the specimen collected by Lowy are of the same form, but slightly larger ($9–11 \times 7–9\,\mu$).

In his discussion of basidiomycete sterigmata, Donk (**1954**) cites the genus *Sirobasidium* as an example of a hymenomycete which produces "slime spores" and lacks violent spore discharge. As has been demonstrated here, violent spore discharge does take place in these fungi, but the epibasidia become detached from the hypobasidium before this occurs. The deciduous epibasidia, which do function as spores, are not slime spores freed through hydrolysis of the fructification. Their peripheral position and loose attachment would indicate that hydraulic force, rather than hydrolytic action, is most important in their dispersal.

In 1945, Maire described a new form, *S. brefeldianum* Möller f. *microsporum,* collected in France, and proposed a new subgenus, *Siro-*

didymia, based on the oblique to transverse basidial septation in this form. Not only is the name invalid, since it was published without a Latin diagnosis, but arrangement of septa is hardly a valid criterion upon which to base subgenera in this genus. Transverse septation of the basidia is not uncommon in most specimens of *Sirobasidium* and is most striking in *S. magnum* Boed., where many of the basidia have three transverse septa. Boedijn (**1934**) contended that, in the latter species, the basidia were produced within the hyphal cells. A specimen of that species which I have examined (Lloyd Mycological Collections, no. *27044,* coll. G. A. Best, Johore, determined by Lloyd as *Tremella undulata* Hoffm.) does not differ from others in this respect. The hyphal segments destined to become basidia often have walls which become progressively thicker, particularly toward either end, where the lumen is usually completely occluded. Thick walls, often laminated in appearance, are not uncommon in the basidia, spores, and hyphae of many tremellaceous fungi. This is most conspicuous in those in which the basidia remain deeply embedded for some time. Aside from this laminated thickening of the walls, there is nothing to suggest that the basidia are formed within the hyphae any more than there is in any other tremellaceous fungus.

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DEPARTMENT OF BOTANY,
STATE UNIVERSITY OF IOWA,
IOWA CITY

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USTILAGINALES OF BIHAR. III.[1] SOME NEW AND INTERESTING SMUTS

J. N. Mishra

(WITH 16 FIGURES)

This contribution is a continuation of the previous studies on the smuts collected from different parts of Bihar. The types have been deposited in the Herbarium C.M.I., Kew, England; Herb. Crypt. Ind. Orient., New Delhi; and in the Mycological Division, Plant Industry Station, Beltsville, Maryland, U.S.A.

Tuburcinia penniseti sp. nov.

Sori in foliis in utroque latere laminae crustas fuscas efformates, 4–6 mm longi, 1–2 mm lati, in textu foliorum immersi. Sporarum bullae luteae vel rubro-luteae colore, ovatae, ca. 120 μ longae, 60 μ latae, saepe coalescentes ad efformandas columnas amplas, constantes e paucis multisve sporis, circumdatae plus minusve serie fragmentorum hyphis similium. Sporae firmiter unitae, subglobosae vel ellipticae, oblongae vel triangulares, subopacae, pallide luteae vel tenuiter rubrae, exosporio crasso levique, 19.5–36 (med. 24.8) μ longae, 12–21 (med. 15) μ latae.

Sori in leaves appearing as dark crusts on both sides of the laminae, 4–6 mm long and 1–2 mm broad, imbedded in leaf tissue. Spore balls yellow to reddish yellow in color, oval, about 120 μ long and 60 μ broad, but frequently coalescing to form large columns, made up of a few to a large number of spores, more or less invested by a layer of hypha-like fragments. Spores firmly united, subglobose to elliptical, oblong to triangular, subopaque, pale yellow to faintly reddish in color, with thick, smooth exospore, measuring 19.5 to 36 (average 24.8) μ in length and 12 to 21 (average 15) μ in breadth.

Habitat: In leaf of *Pennisetum hordeoides*, Netarhat, Bihar, India, 3500 feet above sea level. Collected by J. N. Mishra.

Pennisetum hordeoides is a very common grass of the hill slopes in Bihar and is used as cattle fodder. The plants are very severely infected by the fungus and many leaves wither prematurely. The disease appears to be the greatest handicap in the introduction of *P. hordeoides* as cattle fodder on farms.

[1] The third of a series of papers under the same title, the first two published in Mycologia **48**: 406–408; 872–876. 1956.

Sorosporium capillipedii sp. nov.

Sori penitus destruentes inflorescentiam, lineares, ca. 3-6 cm longi, inclusi vagina persistenti tubulari foliorum. Sporarum bullae evanescentes atque constantes e multis sporis, rotundae vel oblongae atque irregulares, 50–100 μ vel longiores, 30–80 μ latae. Sporae globosae vel polygonales, raro ovatae, oblongae atque angulares, pallide rubro-luteae, episporio fere levi vel tenuiter scabro, 6-9 (med. 7.4) μ diam.

Sori completely destroying inflorescence, linear, about 3 to 6 cm in length, enclosed by persistent tubular leaf sheath. Spore balls evanescent, composed of a large number of spores, round to oblong and irregular, measuring about 50 to 100 μ or more in length and 30 to 80 μ in breadth. Spores globose polygonal, occasionally oval, oblong and angular, pale reddish yellow with almost smooth to slightly roughened epispore, measuring 6 to 9 (average 7.4) μ in diameter.

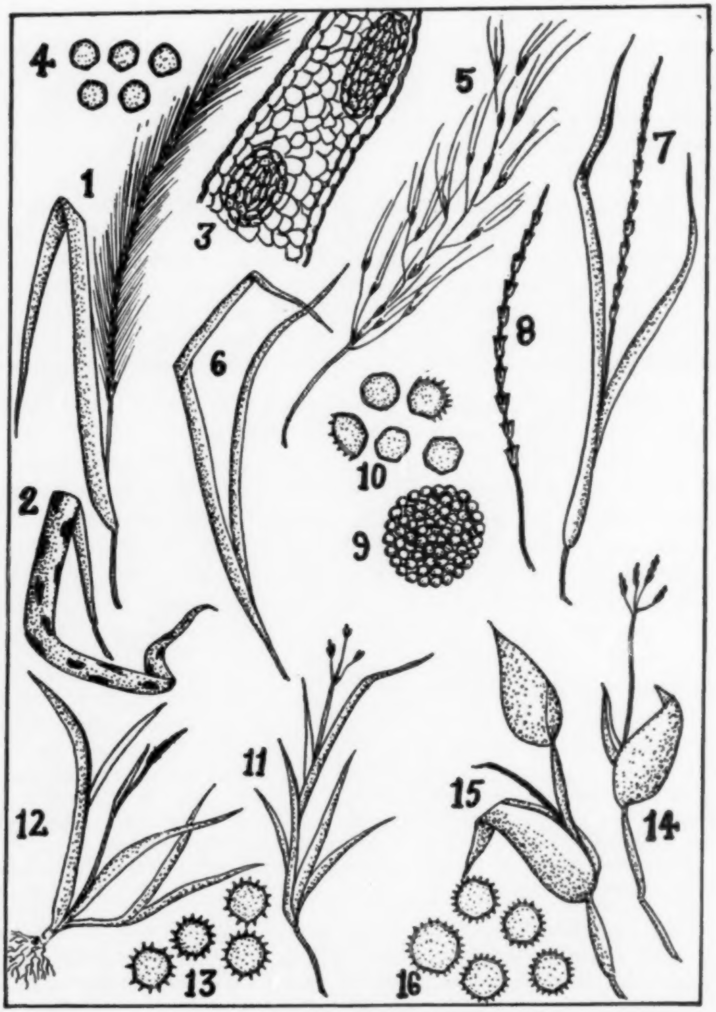
Habitat: In inflorescence of *Capillipedium parviflorum* Stapf, Hazaribagh, Bihar, India. Collected by J. N. Mishra.

Capillipedium parviflorum is a common plant of the grass land of the forests. It was found severely infected by the fungus and the infected plant was very conspicuous by its long, whitish, membranous and tubular leaf sheaths in which the sori are enclosed. The sori do not appear to have any peridium or columella as in *Sphacelotheca capillipedii* Ling, and although the spore balls are evanescent, the polygonal spores are indicative of their having been compressed in spore balls.

Sorosporium mnesitheae sp. nov.

Sori inficientes ovaria omnia, fere aeque ampli ac ovaria normalia, inclusi glumis persistentibus, quae ad maturitatem desidunt ad apicem, ad exponendam massam sporarum nigram, operti peridio persistenti crasso constanti e cellulis quam sporae minoribus, ornati columella simplici tenuique emergenti ex apicibus ut arista minuta. Sporarum bullae permanentes, fusce brunneae, multisporae, ovoideae vel oblongae, 25–60 × 20–45 μ. Sporae pallide rubro-brunneae vel fusce rubrobrunneae, rotundatae vel ovatae, nonnumquam polygonales, delicate verrucosae, 7.5–13.5 (med. 11.5) μ diam.

Sori infecting all ovaries, about as large as the normal ovaries, enclosed in persistent glumes which fall apart at the tip at maturity to expose the black spore mass, covered by a thick persistent peridium of fungoid cells smaller than spores, and with thin simple columellae projecting out at the tips like small awns. Spore balls permanent, deep brown in color, many-spored, ovoid to oblong, measuring about 25 to 60 μ in length and 20 to 45 μ in breadth. Spores reddish to deep reddish brown, round to oval, sometimes polygonal in shape, faintly verrucose on free surface and smooth on the enclosed surface, measuring 7.5 to 13.5 (average 11.5) μ in diameter.



FIGS. 1–16.

FIGS. 1–4. *Tubercinia penniseti.* 1, 2. Healthy shoot and infected leaf of *Pennisetum hordeoides.* 3. Spore balls. 4. Spores, × 160. 5, 6. *Sorosporium capillipedii.* Healthy and infected shoots of *Capillipedium parviflorum.* 7–10. *Sorosporium mnesitheae.* 7, 8. Healthy and smutted spikes of *Mnesithea laevis.* 9.

Habitat: In ovaries of *Mnesithea laevis* (Retz.) Kunth, Nayasarai, Ramgarh, Bihar, India. Collected by J. N. Mishra.

Mnesithea laevis, growing along roadsides, was found severely infected by the fungus. The infected plants were not very conspicuous, as the sori are small and covered by persistent glumes.

Sphacelotheca digitariae-pedicellaris sp. nov.

Sori 1–2 cm longi, penitus destruentes singulas inflorescentias plantae infectae, operti peridio tenui griseoque, quod faciliter in frustula rumpitur, quo fit ut massa sporarum atra patefiat, tenui columella centrali ornata. Sporae pallide rubrae, rotundae vel ovatae, episporio echinulato, 10.5–13.5 (med. 12.2) μ diam.

Sori about 1 to 2 cm in length, completely destroying all inflorescences of the infected plant, covered by a thin gray peridium which flakes away easily to expose the black spore mass, and with thin, simple, central columella. Spores pale reddish, round to oval, with echinulate epispore, measuring 10.5 to 13.5 (average 12.2) μ in diameter.

Habitat: In inflorescence of *Digitaria pedicellaris* Prain (*Paspalum pedicellaris* Train ex Stend.), Nonihat, Bihar, India. Collected by J. N. Mishra.

Digitaria pedicellaris is a common plant of the pasture and hill slopes. The plant was found extensively infected by the fungus. The infected plant was conspicuous by the long smutted ears. The fungus differs from *Sphacelotheca diplospora* (Ell. & Ev.) Clint. as the latter infects ovaries of only a part of the spikelet and has smaller spores.

Sphacelotheca arthraxonis sp. nov.

Sori ca. 1 cm longi, penitus destruentes inflorescentiam, inclusi in vagina persistenti foliorum ad basim et explodentes ad apicem ad patefaciendam massam sporarum nigram tenuiter aggregatarum, ornati columella simplici et acuformi e medio emergenti. Sporae regulares, globosae vel subglobosae, pallide rubrobrunneae vel fusce rubro-brunneae, episporio crasso et bene definito atque nonnumquam secedente ex endosporio, tenuiter sed dense echinulatae vel verrucosae, 10.5–12 (med. 11.4) μ diam.

Sori about 1 cm long, completely destroying inflorescence, enclosed in persistent leaf sheath towards the base and rupturing towards the top to expose the black and slightly agglutinated spore mass, and with a simple and needle-like columellum sticking out from the center. Spores

Spore ball, × 300. 10. Spores, × 600. 11–13. *Sphacelotheca digitariae-pedicellaris.* 11, 12. Healthy and infected plants of *Digitaria pedicillaris.* 13. Spores, × 420. 14–16. *Sphacelotheca arthraxonis.* 14, 15. Healthy and infected shoots of *Arthraxon quartinianus.* 16. Spores, × 500.

regular, globose to subglobose, light reddish brown to deep reddish brown in color, with epispore thick and well-defined and sometimes breaking away from the endospore, faintly but densely echinulate to verrucose, measuring 10.5 to 12 (average 11.4)μ in diameter.

Habitat: In inflorescence of *Arthraxon quartinianus* (Retz.) Kunth, Netarhat, Bihar, India, 3500 feet above sea level. Collected by J. N. Mishra.

TILLETIA VITTATA (Berk.) Mundk. var. **burmannii** var. nov.

Sporae quam in varietate typica minores, 13.5–18 (med. 15)μ diam., marginibus echinulato-verrucosis vel scabris.

Spores smaller than those of the typical variety; 13.5 to 18 (average 15)μ in diameter, with echinulate-verrucose or roughened margin.

Habitat: In ovaries of *Oplismenus burmannii*, Netarhat, Bihar, India, 3500 feet above sea level. Collected by J. N. Mishra.

Tilletia vittata has been described on *Oplismenus compositus* from Parasnath, Bihar. The author found the fungus infecting the host very extensively in the Parasnath hill, but the fungus was not found infecting *Oplismenus burmannii* growing there in abundance. About the same time when *T. vittata* was collected on *O. compositus* in the Parasnath hill, *O. burmannii* was found very severely infected similarly in the Netarhat hill about 200 miles from Parasnath. It was, however, interesting to find that *O. compositus*, growing closely and intermixed, did not show any infection at all. In fact, nowhere in the Netarhat Plateaux has *O. compositus* been found infected by a similar fungus so far. It was, therefore, considered necessary to compare the two collections of *T. vittata* on *O. compositus* from Parasnath and *O. burmannii* from Netarhat. The measurements of 50 dark brown spores are given below.

Host		Size in microns (μ) and frequency (f)				Average
O. compositus	μ	18	19.5	21	22.9	20.5
	f	4	13	29	4	
O. burmannii	μ	13.5	10	16.5	18	15
	f	1	18	30	3	

The spores of *O. compositus* were larger, more regularly globose and the scales were about 1.5 μ long and 0.8 μ broad at the base. In surface view, close and shallow polygonal markings were seen. The hyaline or less dark spores were numerous.

The spores of *O. burmannii* were smaller and much less regular, being mostly elliptical, and the margin appeared echinulate to verrucose

or sometimes only roughened. The polygonal markings on surface view appeared smaller. The hyaline spores appeared much fewer in number.

Though cross inoculations have not been made, it appeared desirable from the above observations to consider the fungus on *O. burmannii* a variety of *T. vittata.*

The author is grateful to the Rev. Father Dr. H. Santapau for preparing the Latin diagnoses.

DIVISION OF PLANT PATHOLOGY,
AGRICULTURAL RESEARCH INSTITUTE,
BIHAR, SABOUR, INDIA

CYLINDROSPORIUM LEAFSPOT OF SPIRAEA [1]

CHARLES L. FERGUS [2]

(WITH 2 FIGURES)

The discovery of a local epidemic of a leafspot disease of *Spiraea vanhouttei* Zabel, caused by a species of *Cylindrosporium,* in a nursery near Ottawa, Kansas, prompted this study. Surprisingly, a survey of various collection records showed that only once before had a *Cylindrosporium* been collected on this host. The results of studies on the life history, taxonomy and physiology of the causal agent, as well as symptomatology and epidemiology of the disease, are presented here.

THE DISEASE SYMPTOMS

The symptoms of the disease are light-yellow lesions which later turn brown as the tissue dies. The size and number of the spots vary on individual leaves. Spots occur on both the upper and lower leaf surfaces (FIG. 1). Those on the upper surface are dark brown, irregular in shape and slightly larger than those on the lower surface. The latter are brownish-orange and irregular in shape but tend to be circular. They are usually 1 to 2 mm in diameter; however, several spots may coalesce and large areas of the leaf, or the entire leaf, may be killed. Severe defoliation may occur in early summer. Examination of microtome sections of affected tissue shows that the cells have been killed and some have collapsed (FIG. 2).

THE CAUSAL ORGANISM

Examination of the lesions on the lower epidermis disclosed large yellow masses of conidia which give a waxy appearance to the lesions on the lower leaf surface. The conidia are extruded from an acervulus (FIG. 2) in large numbers, rupturing the epidermis. The acervuli

[1] Based on work begun at the University of Kansas as an M.A. thesis, and continued at the Pennsylvania State University. Appreciation is hereby expressed to Dr. A. J. Mix for his advice and encouragement during the course of the work.

[2] Contribution No. 210 from the Department of Botany and Plant Pathology, Pennsylvania Agricultural Experiment Station. Authorized for publication August 13, 1956, as paper No. 2085 in the Journal Series.

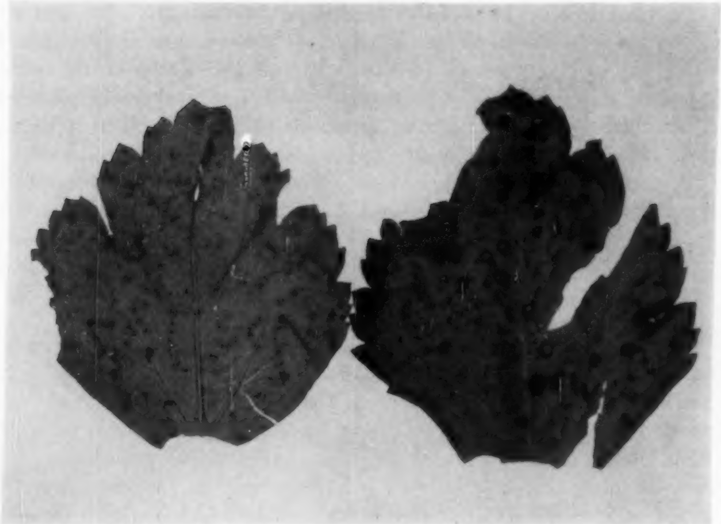


FIG. 1. Upper (right) and lower (left) leaf surface to show characteristic lesions, × 1½.

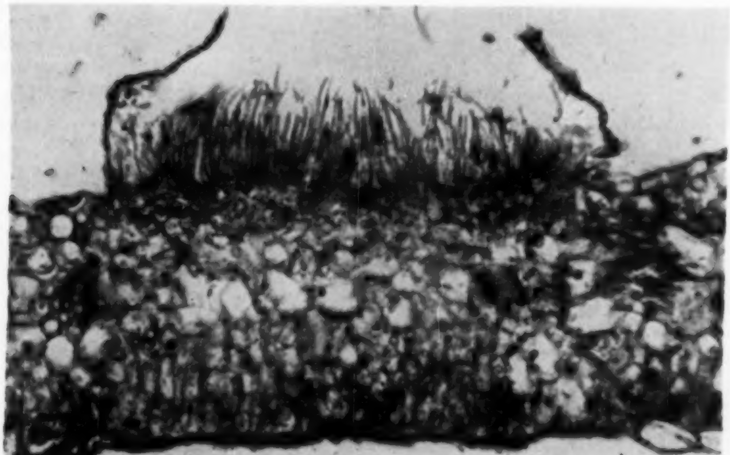


FIG. 2. Acervulus on lower epidermis. Note the appearance of unaffected cells in upper left in contrast to the affected cells, × 450.

range from 140 to 320 μ (average 270 μ) in diameter. Straight or slightly curved conidia are produced at the tips of short conidiophores which vary in length from 2 to 8 microns and 2 to 3 microns in width. The conidia are hyaline, 3–4-guttulate, blunt at the basal tip and pointed at the other, 1-septate, very much agglutinated and difficult to separate, 28–45 $\times$ 2–3 μ in size. The average of 100 spores was 27 $\times$ 2.5 μ.

A perfect stage of the fungus was not found although many overwintered leaves were examined.

TAXONOMY

Various species of *Cylindrosporium* have been listed on species of *Spiraea*. They are: *Cylindrosporium fairmanianum* Sacc., *C. filipendulae* Thuem., *C. salicifoliae* (Trel.) Davis, and *C. spiraeicolum* E. & E. However, only one previous collection of a *Cylindrosporium* had been reported on *S. vanhouttei;* this was by Bliss (**9**) in Iowa in 1927. Gilman and Archer (**9**) identified the fungus as *C. filipendulae*. A study of herbarium specimens [3] led the writer to conclude that the fungus on *S. vanhouttei* collected in Kansas is *C. filipendulae*. In addition, the following conclusions about *Cylindrosporium* spp. on *Spiraea* are also advanced.

C. salicifoliae (Trel.) Davis (**4**) is a synonym of *C. filipendulae* (**14**). Davis (**6**) referred his species to Thuemen's species in his last study.

The descriptions of *C. fairmanianum* Sacc. (**11**) and *C. spiraeicolum* Ell. & Ev. (**8**) appear to refer to the same species. The only difference is the width of the conidia. Examination of many herbarium specimens of these two species shows that the conidial size of *C. spiraeicolum* should be emended to 35–70(–100) $\times$ 3–3.5(–5) μ and that the two species are indistinguishable. Since *C. spiraeicolum* antedates *C. fairmanianum,* the latter should be considered a synonym.

A study of numerous specimens of *C. filipendulae* and *C. spiraeicolum* indicates the probability that these are distinct species, although artificial cross inoculations would be helpful. The acervuli of the latter are almost always epiphyllous, rarely hypophyllous and, if so, there are

[3] The writer wishes to express his appreciation to the following for the loan of herbarium specimens: J. A. Stevenson, National Fungus Collections, Horticultural Crops Research Branch, United States Department of Agriculture; I. McKenzie Lamb, Farlow Herbarium of Cryptogamic Botany; J. C. Gilman, Iowa State College Herbarium; and H. C. Greene, Cryptogamic Herbarium of the University of Wisconsin.

always more acervuli on the upper surface. Conversely, the acervuli of *C. filipendulae* are always hypophyllous. In addition, the conidia of *C. spiraeicolum* are 35–70(–100) × 3–3.5(–5) μ. The conidia of *C. filipendulae* were given by Thuemen (**14**) as 30–35 × 2–3 μ, and should be emended to 35–45(–50) × 2–3(–3.5) μ.

Weiss (**14**) attempts to separate *Cylindrosporium* spp. on the basis of host, listing *C. filipendulae* on exotic species and the other *Cylindrosporium* species, including *C. spiraeicolum* and *C. salicifoliae* (which he names also as *Phleospora salicifoliae* (Trel.) Petrak), on native species. Unfortunately this separation breaks down if *C. salicifoliae* is *C. filipendulae,* for this fungus has been collected on both native and exotic *Spiraea* spp.

Bubak (**3**) and Petrak (**11**) suggested that *Cylindrosporium filipendulae* Thuemen, is *Phleospora filipendulae.* The genus *Phleospora* Wallroth as described by Stevens (**10**), is characterized by the formation of innate pycnidia, imperfectly developed and chiefly formed of modified host tissue. Davis (**5**) and others, including Diedicke (**6**) and Migula (**9**), believe this genus to be a dubious one and interpret it as a mixture of species referable to other genera. They believe it should be abandoned as a usable epithet. It is worth while to note that Archer (**1**) worked extensively with the Sphaeropsidales, but did not suggest that the fruiting body of this fungus was anything other than an acervulus.

Examination of many microtome and free-hand razor sections of the fructification of *C. filipendulae* in various stages of its development failed to reveal the presence of tissue which could be interpreted as a pycnidial wall. It would therefore appear that the proper genus for this fungus is the genus *Cylindrosporium* of the order Melanconiales. The following synonymy is listed for the sake of clarity.

CYLINDROSPORIUM FILIPENDULAE Thuemen (**14**)
Ascochyta salicifoliae Trel. (**15**)
Septoria salicifoliae Berl. and Vogl. (**2**)
Phleospora salicifoliae (Trel.) Bubak (**3**)
Cylindrosporium salicifoliae (Trel.) David (**4**)
Phleospora salicifoliae (Trel.) Petr. (**13**)

An examination of herbarium specimens and various reports (**9, 16**) reveals the following host range: *Spiraea alba* var. *lanceolata, S. corymbosa, S. densiflora, S. douglasi, S. filipendula, S. lucida, S. margarita S. prunifolia, S. pyramidata, S. salicifolia, S. thunbergii, S. tomentosa* and *S. vanhouttei.*

GROWTH AND SPORULATION IN CULTURE

Growth and sporulation of eight isolates of *C. filipendulae* on potato-dextrose agar, lima bean agar, lima bean-maltose agar and Coons' agar[4] were studied. The fungus grew slowly on all media, never covering all the agar surface even after 14 days' growth. Maximum growth (5 cm colony diameter) occurred on Coons' agar, with potato-dextrose, lima bean-maltose and lima bean allowing growth in that order.

The appearance of the mycelium varied on the different media. A closely appressed and partially submerged mat of mycelium formed. Older cultures developed some aerial hyphae. The mat varied in consistency from tough to membranous and varied in color through shades of cream, yellow and tan. A light yellow diffusible pigment was usually produced.

Conidia formed on short branches of the submerged hyphae. Sporulation was about equal on all agar media, but it was slightly better on Coons' agar. The addition of 1 percent maltose to lima bean agar increased mycelial formation but reduced sporulation from that on lima bean agar.

The ability of the fungus to utilize various compounds as carbon sources was tested by deleting the maltose in Coons' medium and substituting various sugars singly. Growth was best on maltose, practically the same on glucose, sucrose and fructose, but poor on galactose and lactose. The availability of nitrogenous compounds was tested in a similar manner by deleting the potassium nitrate and substituting singly various compounds. Good growth was observed on nitrates, ammonium compounds and some organic nitrogenous compounds. Sporulation was also good on most of the nitrogen media tested. Urea was an exception, for both growth and sporulation were sparse on the urea medium.

SPORE GERMINATION

Infected leaves were placed in moist chambers for 48 hours at room temperature. Extruded spores were picked off the acervulus with a sterile needle and ground in sterile distilled water. A loopful of the spore suspension was placed in a drop of the test solution on a sterile microscope slide and incubated 48 hours in a moist chamber. Each solution was tested in triplicate and all germinated and non-germinated conidia observed in six microscopic low power fields were used to determine percentage germination.

[4] The composition is: maltose 10 gms, $MgSO_4$ 1.23 gms, KH_2PO_4 2.7 gms, KNO_3 2.02 gms, agar 20 gms, and dist. water to make 1 liter.

Germination in tap water, rain water and distilled water was low, 18–25 percent. Increased germination (up to 81 percent) was observed in solutions containing various sugars (0.5 and 1.0 percent concentration). Asparagin (92 percent) and peptone also stimulated germination over that observed in distilled water. Minerals did not allow increased germination. The length of germ tubes was measured at the end of 48 hours and in those solutions allowing the maximum number of spores to germinate, maximum germ tube elongation occurred; e.g. in distilled water, germ tubes averaged 17 microns, whereas in maltose (75 percent germination) germ tubes averaged 97 microns.

EPIDEMIOLOGY

Rainfall and temperature records for May and June of 1938, 1939 and 1940 were correlated with disease severity. Disease incidence was high in 1938 and 1940, but low in 1939. The high disease incidence was correlated with temperatures lower than normal in May and June and with heavier rainfall than normal.

Interestingly, although hundreds of plants were infected in the nursery plot, no infection was found in the nearby town of Ottawa, Kansas, nor in Lawrence, Kansas. The writer has frequently examined *Spiraea vanhouttei* throughout the growing season for the possible occurrence of the fungus, not only in Kansas, but also in Pennsylvania for about 10 years. To date no other collections on this host have been made, nor has anyone else reported finding the fungus on *Spiraea vanhouttei*.

THE DEPARTMENT OF BOTANY AND PLANT PATHOLOGY,
PENNSYLVANIA STATE UNIVERSITY,
UNIVERSITY PARK, PENNSYLVANIA

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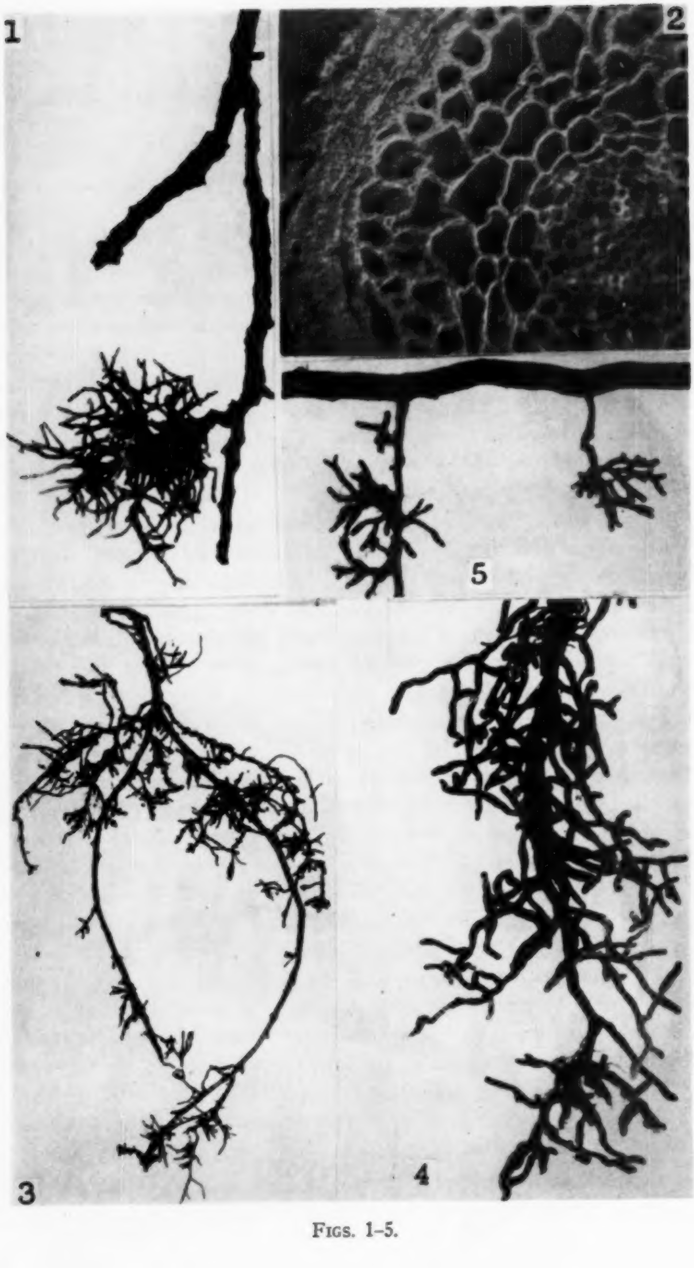
OCCURRENCE OF MYCORRHIZA ON SOME INDIAN CONIFERS

B. K. Bakshi

(WITH 5 FIGURES)

Our knowledge of mycorrhiza on Indian trees is scanty. Rayner (**1945**) reproduced an illustration (pl. 18) to show the role of mycorrhiza on chir (*Pinus roxburghii*), an Indian conifer grown as an exotic in Rhodesia, Africa. The chir nursery in Rhodesia, which was a failure due to the absence of the mycorrhiza-forming fungus, became successful when such a fungus was introduced in the nursery with the soil from a successful plantation of the species. The only other published record is by Chaudhuri (**1945**) who reported endotrophic mycorrhiza in five Indian conifers: *Pinus roxburghii* (= *Pinus longifolia*), *Cedrus deodara, Picea morinda, Abies spectabilis* and *Taxus baccata*. The observations appear doubtful, since in the Abietineae, in which all the above conifers except *T. baccata* belong, the mycorrhiza is usually ectotrophic. *T. baccata,* however, possesses endotrophic mycorrhiza. In germination experiments, Chaudhuri could induce development of ectotrophic mycorrhiza in *P. roxburghii* and *C. deodara* (and thus different from endotrophic form as stated earlier for the species), by inoculating these plants with the appropriate fungi. The statements thus appear contradictory. In view of this, a re-examination of mycorrhiza in Indian conifers was considered desirable. The following account gives illustrated descriptions of mycorrhiza in *Cedrus deodara* (deodar), *Picea morinda* (spruce), *Abies pindrow* (fir) and *Pinus roxburghii* (chir).

Deodar, spruce and fir have been studied in their natural habitat in the temperate regions of the Western Himalayas, Chakrata division, Uttar Pradesh State; at altitudes of 6000–8000 ft. Chir was examined in plantations raised in the New Forest (altitude about 2000 ft). In all the above trees, the root system is heterorhizic and two broad types are recognized —long roots of unlimited growth which are uninfected and short roots of limited growth which usually become infected by a fungus to form a mycorrhiza. Generally, in all the four conifers studied, the mycorrhiza is ectotrophic, the short roots being completely enveloped by the hyphae of the infecting fungus forming a pseudoparenchyma a few cell-layers thick and called the fungus mantle. Within such roots, hyphae occur



FIGS. 1–5.

in the intercellular spaces of the outer cortical cells forming a network —the "Hartig net." All short roots are ephemeral. Brief descriptions of mycorrhizal short roots in the four conifers are given below:

DEODAR. The mycorrhizal roots in deodar are coralloid and the coralloid branches (FIG. 1) cluster thickly at various places on lateral roots to appear like witches' brooms. The mother root is of limited growth, about 1–1.5 cm long, and bears short roots laterally. The short roots are 1–5 mm long, 0.3–0.4 mm broad, swelling to 0.7 mm at the distal ends, brown when active, turning black and brittle when functionless, unbranched. Both mother root and short root usually become infected by a fungus which forms a dense covering of fine loose, silky hyphae which are hyaline or nearly so, rarely branched, with clamp connections, 2–3 μ broad. The fungus mantle over infected roots is up to 25 μ thick and consists of 8–12 cell layers (FIG. 2). Setal hyphae from the fungus mantle were observed in some cases. Hyphae occur in the intercellular spaces of the outer 2–3 cortical cells (FIG. 2).

SPRUCE. Spruce possesses simple mycorrhiza where the mother root, up to 1 cm long, bears the short roots racemosely (FIG. 3). The latter are up to 4 mm long, 0.2–0.3 mm broad, swelling to 0.4 mm at the distal end. They are unbranched, pink when active, black when inactive. Both mother root and short root are mycorrhizal and the superficial hyphae on them, which form a dense covering, are hyaline, thin-walled or slightly thick-walled with simple septa and clamp connections, up to 0.4 mm long, 2–3.5 μ broad. The fungus mantle over infected roots is up to 30 μ thick and consists of 14–16 closely compacted cell layers. Intercellular hyphae occur in the outer 1–2 layers of the cortical cells.

FIR. The mycorrhizal roots in fir are simple, like those of spruce. The mother root may be up to 1.5 cm long (sometimes longer) and bears laterally short roots (FIG. 4) which are usually unbranched, pinkish brown when fresh, black when functionless, average 3–4 mm in length (sometimes up to 8 mm), 0.4–0.5 mm in width, swelling to 0.7 mm at the tips. The wefts of loose hyphae on the short roots are less abundant. The hyphae are hyaline or light brown, branched or unbranched, the septa simple, or rarely with clamp connections, 30–60(–100) $\times$ 3–4 μ. The fungus mantle over infected roots is 20–30 μ

FIGS. 1–5. Mycorrhiza on conifers. 1. Long and short roots from deodar, $\times$ 1.5. 2. Transverse section of short root of deodar, showing fungus mantle and Hartig net, $\times$ 160. 3. Root system of spruce, showing long and short roots, $\times$ 1.3. 4. Long and short roots of a 3-year-old fir seedling, $\times$ 2.6. 5. Long and short roots of a 10-year-old chir, $\times$ 1.8.

thick and consists of 10–12 layers of hyphae. A Hartig net is present in the outer 2 cortical cell layers.

CHIR. Repeated dichotomy at short intervals, usually within 1 mm, characterize the short roots of chir (FIG. 5) from other conifers described above. These short roots are usually borne directly on the uninfected lateral roots. The short roots are usually less than 1 mm, sometimes up to 2–3 mm long, 0.4–0.5 mm wide, pink when fresh, with distal ends not appreciably swollen. The weft of hyphae is loose, up to 2 mm long, branched, with clamp connections, 2–3 μ broad. The fungus mantle over the short root is 20–25 μ thick and consists of about 8 cell layers. A Hartig net is present in the outer 2–3 layers of cortical cells.

Detailed morphological, anatomical and development studies of the short roots and the significance of mycorrhizae in these trees are in progress.

FOREST RESEARCH INSTITUTE,
DEHRA DUN, INDIA

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NOTES ON LONGULA TEXENSIS VAR. MAJOR [1, 2]

Paul R. Harding, Jr.

(with 2 figures)

What seems to be a noteworthy collection of this unusual gasteromycete (Fig. 1) was made by the writer on May 6, 1956, at the mouth of Andreas Canyon near Palm Springs, California. The fungus was growing near a stream in sand shaded by the fan palm, *Washingtonia filifera.*

No complete description of this fungus seems to be available in the literature, particularly as drawn from fresh material and taking into account microscopic characters. It is my hope that the following description will be useful in furthering our understanding of this species.

Pileus subglobose, 7–7.5 cm in diameter, white, becoming yellowish, densely and coarsely scaly, firm, not viscid. Pileus with three layers: an outer volval layer, a middle cuticular layer, and an inner tramal layer which supports the glebal lamellae. The scaliness is the result of break-up of the volva and cutis. Pileus remaining closed at maturity; the gleba not exposed except in age when tearing and general breakdown of the lower part of the pileus make the lamellae visible. Stipe cylindrical, 9.5–10 × 3–4.5 cm (excluding the columella), concolorous with the pileus, firm, solid, with white pith-like interior and tough rind 2–3 mm thick, smooth to rimose-areolate, sheathed with adherent patch-like remains of the volva which forms a membranous annulus around the lower edge of the pileus. Stipe tapering centrally through the gleba to form a percurrent columella measuring 6 × 1.5–3 cm and having a rind 1–1.5 mm thick. Several white rhizinae are present at the base of the stipe. Gleba composed of vertically arranged, wavy, anastomosing lamellae which are grayish at first, becoming dark brown, then black. Although in contact with the columella, the lamellae show no definite attachment to any part of that structure, but are attached full-length to

[1] This work is not connected with the author's assigned research; moreover, it has been done outside of official hours, and all statements are entirely his responsibility.

[2] Miss Elizabeth E. Morse was greatly interested in the *Longula-Gyrophragmium* problem and repeatedly referred to it in her letters. Had she been able to complete the paper on which she was working during her last years, I am sure that her conclusions would have been in entire agreement with those of Dr. Harding. I stated this in correspondence with Dr. Harding, and at his request I am inserting this note.—G. W. Martin.

FIG. 1. *Longula texensis* var. *major*. Carpophores, approx. × ¾.

the inner side of the pileus. Spores subglobose, 5–7(–8) μ in diameter, black in mass, light brown to dark brown or black under the microscope, smooth, thick-walled, with hyaline apiculate hilum, without detectable germ pore. The spores are not discharged, but remain on the hymenium. Basidia clavate, 20–25 × 7–8 μ, thin-walled, hyaline, mostly 4-spored, occasionally 2-spored. Lactiferous basidioles scarce, yellowish. Cystidioid cells 40–50 × 15–20 μ scattered in hymenium. These are

FIG. 2. *Longula texensis* var. *major*. Carpophores, approx. $\times \frac{3}{4}$, showing median section.

saccate to vesiculose, thin-walled, hyaline, and project 15–20 μ beyond the basidia. Tramata of the glebal lamellae composed of parallel hyphae which are 3–6 μ in diameter, septate, thin-walled, hyaline; a few yellowish lactiferous hyphae present, measuring 4–7 μ in diameter.

The entire carpophore is covered at first with a white sheathing adherent membranous volva which later appears as white to cream colored patches on the stipe and on the pileus scales. The volva also forms a membranous annulus attached to the stipe and margin of the pileus. In my interpretation, a partial veil is lacking and the annulus is derived from the sheathing universal veil or volva. This interpreta-

tion would seem to place the plant back in the genus *Gyrophragmium* where Lloyd (**3**) disposed of it as *G. decipiens.* The basidia lack ability to discharge the spores, and this is the principal reason that modern taxonomists consider the plant a gasteromycete rather than an agaric. No clamp connections were seen on any of the hyphae. The columella is not expanded above, and is of distinctly different tissue from that of the pileus. This is apparent in the photograph of the median section (FIG. 2). The spores germinate readily when masses are streaked on nutrient agar, to produce a white mycelium which, when examined microscopically, is seen to be composed of hyphae lacking clamp connections.

Exactly how *Longula texensis* var. *major* Zeller (**4**) differs, other than in size, from *Longula texensis* (Berk. & Curt.) var. *texensis,* is not clear. The latter has been described by Zeller (**4**, **5**, **6**) and Barnett (**1**) as being annulate from a partial veil, rather than from a universal veil. I doubt if this can be the case. The perpetuation of the concept (**2**) of the genus *Longula* as characterized by a two-layered or double annulus derived from a partial veil and as having no volva, is in disagreement with my interpretation based on observation of fresh material (P. R. Harding, Jr. *578* and *499*, now in herbarium of Rancho Santa Ana Botanic Garden, Claremont, Cal.) of both of the above forms. I hold that the stipe is annulate from the sheathing universal veil or volva to form the lower layer, and that the upper ring, when present, is the remains of the pileus margin, the partial veil being absent. If a partial veil were present, it would extend from the edge of the pileus to the top of the columella. This condition does not exist, even in the button stage.

I am indebted to Dr. G. L. Rygg for photographing the specimens.

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ELSINOË ON SOUTHERN RED OAK

JULIAN H. MILLER[1]

(WITH 1 FIGURE)

During 1948–54 several specimens of minutely as well as abundantly spotted leaves of southern red oak (*Quercus falcata* Michx.) from Georgia and North Carolina were received for identification in the Department of Plant Pathology and Plant Breeding, College of Agriculture, University of Georgia. *Sphaceloma* was identified on the earliest specimen (see "Specimens cited") and the disease recorded by Jenkins and Bitancourt (**1**) as a spot anthracnose. With the *Elsinoë* stage of the fungus present on specimens subsequently received, the organism is here recognized as a new species of that genus.

Elsinoë quercus-falcatae sp. nov.

Maculae epiphyllae, parcae vel abundantes, per duas partes laminae dispersae, rotundulae vel irregulares, 0.3–1.2 mm in diam., nigro-brunneae centro saepe pallidiores, coalescentes et tunc areas magnas irregulares necroticas efficientes; ascomata intraepidermicalia, erumpentia, ad cellas gummi-impletas parenchymatis foliaris superimposita, e pseudoparenchymate hyalino composita et strato nigro-brunneo cellularum epithelii 4–6 μ crassarum tecta, $100–150 \times 35–60\ \mu$, ex ascis globosis 20 μ in diam. irregulariter impleta; ascosporae 2–4-cellulares, $11–14 \times 4–6\ \mu$; acervuli *Sphacelomatis* intraepidermicales, erumpentes, parvi; conidiophora crassitunicata, pyriformia, pauca vel pluria in fasciculis conicis unita, $10–14 \times 6–8\ \mu$, strato tenui plectenchymatis hyalini ad cellas gummiimpletas folii superimposito directe oriundis; conidia von visa.

Leaf spots epiphyllous, few to abundant, scattered over as much as two-thirds the surface of the leaf blade, roundish to irregular, 0.3 to 1.2 mm in diameter, "blackish brown,"[2] often lighter colored at the center, coalescing when abundant and forming large irregular areas where the tissue is killed and browned on both leaf surfaces. Ascomata intraepidermal, erumpent, placed on top of the gum-filled cells of the palisade parenchyma of the leaf, made up of a hyaline pseudoparen-

[1] In the present study the writer acknowledges with pleasure the contribution of specimens by those named under "Specimens cited," also the collaboration in various ways by Drs. A. A. Bitancourt and Anna E. Jenkins, finally, that of Edith K. Cash, who translated the diagnosis into Latin.

[2] Color reading based on Ridgway (**2**).

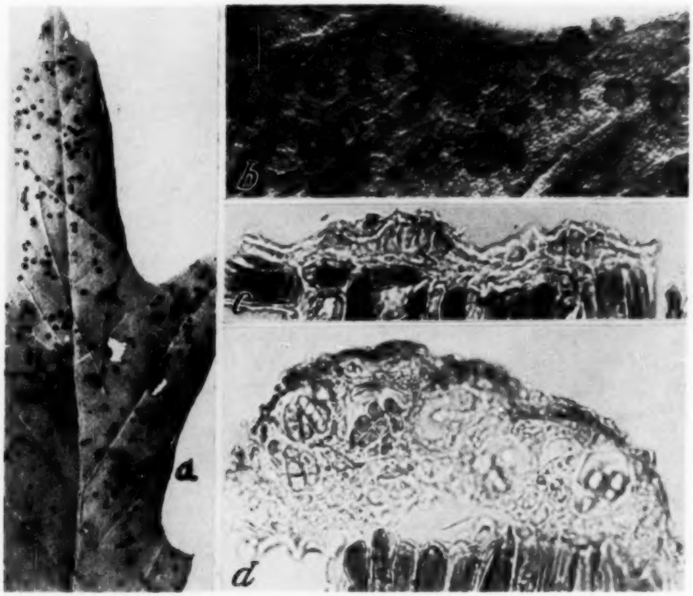

FIG. 1. *Elsinoë quercus-falcatae* on *Quercus falcata*, upper leaf surface. a. Leaf spot, natural size. b. Part of a, × 5. c. and d. In section, acervuli (c) and an ascoma (d), both × 500. Specimens represented, those from Macon (a–c) and Stevens County (d), Georgia. Photographs contributed by Jenkins (a–b) and Bitancourt (c–d).

chyma, covered with a dark brown layer of epithecial cells, 4–6 μ thick, 100–150 × 35–60 μ, irregularly filled with globose asci, 20 μ in diameter, containing hyaline 2–4-celled ascospores, 11–14 × 4–6 μ.

Acervuli of the imperfect stage (*Sphaceloma*) intraepidermal, erumpent, small, with dark brown, thick-walled, pear-shaped conidiophores, united in conical bundles of a few to several, 10–14 × 6–8 μ, arising directly from a thin hyaline plectenchyma resting on top of the gum-filled palisade cells of the leaf. Conidia not seen.

On living leaves of *Quercus falcata* Michx. (Fagaceae), Georgia and North Carolina, U. S. A., causing spot anthracnose of southern red oak.

The first visible symptoms appeared on the Stephens Co., Ga., tree in early June and increased progressively until the middle of August. At that time all leaves were heavily infected, with the entire tree appearing yellow, and this was followed by some defoliation.

This fungus develops the ascomycete stage in late summer on leaves still on the tree or recently fallen. The time is approximately the same as for *Elsinoë corni* Jenk. & Bitan. and much later than the appearance of the ascocarps of *E. magnoliae* Mill. & Jenk. As is true for these species, *E. quercus-falcatae* dies soon after the leaves fall.

In the years of observation the trees are still living but limbs that were most heavily infected are now dead. The disease does not spread rapidly to other oaks of the above species and has not been found on any other species. Specimens examined:

GEORGIA: Macon, August 1948, coll. and comm. B. C. Reid and F. R. Lancaster, respectively, both of the Davy Tree Expert Company. *Sphaceloma* stage. Provisional identification as *Sphaceloma* by G. H. Thompson verified at his request by A. E. Jenkins and A. A. Bitancourt (HG, IB *5320*, NFC *90602*);[3] Stephens County (about 60 mi. n. of Athens), August 1953, coll. and comm. Nelson Brightwell, Extension Forester. Perfect stage. (Type, HG, IB *6101*, NFC *91269*.)

NORTH CAROLINA: Charlotte, August 1937, coll. and comm. G. H. Hepting, Division of Forest Disease Research, Southeastern Forest Experiment Station, U. S. Forest Service, Asheville, N. Car. Perfect stage (HG, HNC); Mount Airy, August 1953, G. R. Fuller, comm. J. S. Boyce, Jr., Div. For. Dis. Res., S.E.F.E.S., U.S.F.S. Perfect stage (HG, HNC, IB *6062*); on fallen leaves, Marion, Feb. 5, 1954, H. E. Ertel, Asplundh Tree Company, comm. G. H. Hepting (HC, IB *6211*, NFC *91272*).

DEPARTMENT OF PLANT PATHOLOGY AND PLANT BREEDING,
UNIVERSITY OF GEORGIA,
ATHENS, GEORGIA

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[3] Abbreviations employed in the citation of specimens: HG—Herbarium, Dept. Plant Path. & Plant Breeding, Coll. of Agri., Univ. of Ga., Athens, Ga. HNC—Herbarium, Division of Forest Disease Research, Southeastern For. Exp. Sta., Asheville, N. Car. IB—Herbario, Secção de Fitopatologia do Instituto Biológico, São Paulo, Brazil. NFC—National Fungus Collections, Plant Disease Epidemics and Identification Section, ARS, U. S. Dept. Agr., Beltsville, Md.

IS MYCOTYPHA A PHYCOMYCETE?

F. A. Wolf

(with 1 figure)

In **1932**, Fenner described *Mycotypha microspora*, placing it among the Mucoraceae. This genus remained monotypic until recently (Wolf, **1955**) when an organism, designated *Mycotypha dichotoma*, was reported to occur on pine seed and soil in the greenhouses at Duke University. While this report was in press, Margaret E. Barr collected the same fungus in the greenhouses at the University of Michigan. And, during the past summer, while at Harrow, Ontario, the writer observed that the identical fungus was present on soil in a greenhouse used by Dr. A. A. Hildebrand for the cultivation of soybeans.

In greenhouses at Berlin-Dahlem, Germany, Schneider (**1954**) collected a disc fungus which she described as a new species of Pezizaceae, giving it the name *Plicaria fulva*. She isolated it from ascospores germinated on beer-wort agar, on which medium a conidial stage developed within a few days. But she did not assign a generic name to this conidial stage nor indicate its taxonomic position beyond stating that it is related to *Rhinotrichum* Corda and *Botrytis* Micheli. As judged from her description and drawings, however, the morphology of the conidial stage of *Plicaria fulva* accords well with that of *Mycotypha dichotoma*, as described by the writer. In fact little doubt remains that it is identical with *M. dichotoma*.

As bearing on the taxonomic position of the conidial stage of *Plicaria fulva*, it should be emphasized that a proper generic name has never been assigned to an organism having the characters depicted for it by Schneider, and erroneously identified as *Mycotypha* by the writer. Both *Rhinotrichum* and *Botrytis*, to which genera she believed the conidial stage is related, are in the same group with *Oedocephalum*. It may be recalled that Dodge (**1937**) identified the conidial stage of *Peziza pustulata* as belonging to *Oedocephalum*. This genus is now generally held by mycologists to be among the Moniliaceae, although some have interpreted it as being phycomycetous.

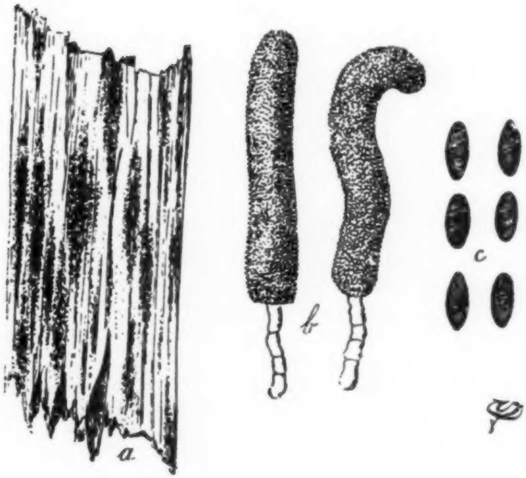

FIG. 1. *Microtypha saccharicola* Speg. Original illustration, slightly reduced. Photograph supplied through the courtesy of Mr. John A. Stevenson.

Through the courtesy of Dr. G. W. Martin and Dr. C. J. Alexopoulos, a culture of *Mycotypha microspora* was recently made available to the writer, who was not aware that such a culture existed. From comparison of this culture with those of *M. dichotoma* it is concluded that the two species are not congeneric. Furthermore, in my opinion, it is very doubtful that *M. microspora* is a phycomycete, because its hyphae are septate, and it possesses brown pigment. Such features suggest that it may be among the Dematiaceae, resembling most closely *Microtypha*, as described by Spegazzini (**1910**). He stated that this genus is dematiaceous, its fertile hyphae erect and septate; its conidiophores stand singly, with slender stipes, each with a club-shaped conidium-bearing portion, that is minutely and roughly papillate, each papilla bearing a single conidium. The conidia form a cylindric mass, are densely aggregated, and brown. Certainly this description resembles closely that of *Mycotypha* but whether *Microtypha* and *Mycotypha* are identical remains a matter for further study.

As an outcome of these further considerations it may now be stated that *Mycotypha dichotoma* is not a peculiar Phycomycete, but belongs to an unnamed form genus that occupies a position near *Oedocephalum*,

Botrytis and *Rhinotrichum*, among the Moniliaceae. That *Mycotypha* and *Microtypha* may be identical seems probable.

DEPARTMENT OF BOTANY,
DUKE UNIVERSITY,
DURHAM, NORTH CAROLINA

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CORNELIUS LOTT SHEAR

John A. Stevenson

(with portrait)

With the death on Feb. 2, 1956, of Dr. C. L. Shear, botanical science, and mycology in particular, lost one of its outstanding contributors. For more than fifty years he took a prominent part in its advancement, working with equal facility in the basic science of mycology and in the applied field of phytopathology. An account of his life, personality, and scientific accomplishments will be presented here.

Cornelius Lott Shear was born in Coeyman's Hollow, Albany Co., New York, March 26, 1865. He grew up in the village and on an adjoining farm, attending country schools as circumstances permitted. His surroundings inevitably led to an interest in plant life, aided greatly by his mother and the family physician. The latter loaned him books which he would not otherwise have had access to and encouraged him in other ways. As a boy in his teens he acquired a folding magnifying glass which he used throughout his life.

His early studies were of the flowering plants, but he turned to the fungi during his years at the Albany State Normal School, from which he graduated in 1888. One of his instructors here was E. A. Burt, who himself became one of America's noted mycologists. In Albany Shear became acquainted with Charles H. Peck, the pioneer New York State botanist, and they remained close friends until Peck's death, collecting together on several occasions and corresponding rather regularly until 1912. Peck named many of Shear's early fungus collections from New York, Nebraska, and the region of the District of Columbia, publishing a number of them as new.

Following graduation there were a number of years of school teaching and a brief experience as secretary of a teacher's agency. One school year was spent at Hartsdale, New York, with easy access to New York City and Shear seized the opportunity to explore on week-ends the artistic and scientific possibilities of the metropolis. Here he met Dr. and Mrs. N. L. Britton, H. H. Rusby and other local botanists who encouraged him in his ambition for a botanical career. Through Dr. Britton's interest his first botanical note was published in the Bulletin of the Torrey Botanical Club. During this year he purchased a micro-

C. L. SHEAR
WITH JOHN DEARNESS
Gatlinburg, Tennessee, August, 1939

scope and on the advice of Peck acquired his first mycological book, Plowright's British Uredineae and Ustilagineae.

A second year of teaching grammar school at Stockbridge, Massachusetts, gave further opportunity for botanizing and in a new region. While teaching here he was married on December 25, 1890 to Avis M. Sherwood at her home in Osborne, Kansas, beginning a happy married life of nearly sixty years.

Several years of teaching followed at Alcove, New York, where his parents had taken up residence. During these years he actively collected the fungi of the region and issued two centuries of his exsiccati under the title, New York Fungi. A third century, again using Alcove material, was issued from Lincoln, Nebraska, in 1896. The sale of these sets helped materially in the support of his family. His first papers in mycology were also published during this period as popular accounts of the common mushrooms. His collections, however, covered all groups of the fungi and were so extensive that after more than 60 years some still repose in the unworked accumulations of the National Fungus Collections at Beltsville.

Shear never found teaching a congenial occupation and, like Mr. Micawber, he ruefully noted that the "pecuniary emoluments" were very unsatisfactory. Hoping to improve his situation he moved with his family to Osborne, Kansas, in 1894 to live with his wife's parents and while there taught a term of country school and collected plants for sale. The proceeds from the latter enterprise exceeded his salary as teacher.

He had never given up hope of a college education and an opportunity to gain a livelihood as a botanist, so that when Dr. Bessey of the University of Nebraska offered him an undergraduate fellowship of $250 for 10 months he accepted against the advice of his wife's relatives, but with the complete acquiescence of his wife. An appointment with the Division of Agrostology of the United States Department of Agriculture for field studies of grasses and other possible forage plants during the summers at the enormous salary of $150 per month and expenses made it possible to support a growing family and graduate in 1897 with a B.S. degree.

A year of graduate work eventually resulted in a Master's degree. During his years at Nebraska, Shear had as associates such future botanical notables as F. E. Clements, Ernst Bessey, Roscoe Pound, P. A. Rydberg and R. K. Beattie, with whom lasting friendships were established.

Lamson-Scribner, Chief of the Division of Agrostology, was favorably impressed with Shear's field work and he was accordingly given a

permanent appointment in 1898 as Assistant Agrostologist with headquarters in Washington. He served in this capacity until 1901, publishing the results of his studies in a number of Department publications, a monograph of the genus *Bromus* being particularly noteworthy.

An agrostologist officially, but always a mycologist at heart, Shear worked away at the fungi out of official hours and published a series of papers on the mushrooms and puffballs in the Asa Gray Bulletin and other popular scientific periodicals of the time. He also took over the preparation and sale of the exsiccati Fungi Columbiani from J. B. Ellis, issuing Century XV, but thereafter pressure of other duties caused him to turn this task over to E. Bartholomew. The Asa Gray Bulletin which he had been instrumental in founding in his Alcove days again came into his hands and he was both editor and publisher until the Journal was absorbed by the Plant World in 1901. He was also active in the short-lived Washington Mycological Club, with a membership for the most part from Department of Agriculture employees living in Takoma Park, a Washington suburb.

With the formation of the Bureau of Plant Industry in 1901 Shear gladly turned to a position in "vegetable pathology" which allowed him full time with the fungi. He entered the profession at a time when plant pathology was essentially "applied mycology" and it was from this point of view that Shear carried on his studies in plant diseases. He was primarily interested in the life histories of the fungus pathogens and their taxonomy. Control measures were by no means neglected, however, and during the early years of his phytopathological career he diligently worked out spray programs and other methods of checking fungus attacks. However, there is no doubt but that he would have preferred to confine his efforts to the fungi.

He was first assigned to study the fungus diseases of cranberry and within a short time was given the responsibility of directing all Bureau work with small fruit diseases, which added to his field of activity the diseases of *Vitis, Fragaria, Rubus, Ribes* and other *Vaccinium* species. He attacked all phases of the cranberry disease problem, working alone at first, but in later years with assistants, notable of whom were N. E. Stevens and H. F. Bain. A comprehensive account of cranberry diseases was published in 1907 and also used as a dissertation for the Ph.D. degree granted in 1906 by the George Washington University. Alone or in collaboration he published nearly 30 other papers on various phases of the problem of cranberry pathology.

Beginning in 1903 he was for a time associated with the work on cotton root rot, a disease then serious in Texas. He gave particular

attention to the etiology of the disease, named the fungus culprit and joined in the search for control measures. Several papers resulted from these studies.

Heavy losses from fungus diseases of the grape had led to the pioneer work in plant pathology of Lamson Scribner and his successor B. T. Galloway. Shear, with his small fruit disease project, continued in the tradition of studying grape diseases, giving particular attention to the fungi causing black-rot, dead-arm, anthracnose and rust. His progress was marked by his usual excellent technical publications together with popular treatises on the grape and its diseases. Similar studies were made of certain diseases of the strawberry and other small fruits, but the work with these fruits was largely turned over to associates working under his direction.

In the course of his studies of the fungi associated with the various fruit diseases he frequently encountered, of course, the so-called anthracnose fungi. Mycologists had been in the habit of setting up a new species for each new anthracnose host discovered, a common practice with many fungus groups that has not as yet disappeared completely from the mycological world. Shear assembled specimens and cultures from many sources and demonstrated after careful morphological and cultural studies that the anthracnose fungus complex could be largely resolved into an Ascomycete, *Glomerella cingulata,* and its conidial stage previously referred to a great variety of names in the form genera *Colletotrichum* and *Gloeosporium.* In this piece of classical mycological research he indicated clearly his life-long preference for careful and detailed studies which usually permitted him to reduce many bionomials to synonymy rather than indiscriminately adding "new species" to an already overburdened taxonomy.

The Pyrenomycetes always intrigued him and he gave much attention to them throughout his career since many of them were involved as pathogens of the small fruits included in his official project. *Physalospora* and *Botryosphaeria* and their conidial stages in the genera *Diplodia, Dothiorella,* and *Sphaeropsis* were thoroughly studied in cooperation with N. E. Stevens and M. S. Wilcox. For this purpose hundreds of collections were assembled by field trips throughout many parts of the country and the study of herbarium material in the Bureau collections and in similar institutions here and abroad.

Similar attention was given to the genus *Endothia* during the chestnut blight disaster. Shear travelled extensively in Europe in 1912, studying in the herbaria and examining chestnut forests throughout southern Europe for *Endothia* material. It was established beyond

doubt that *E. parasitica* was an Asiatic species rather than a native American species which had developed bad habits. Shear and Stevens collaborated in a monographic account of the chestnut blight fungus and its relatives. Many other thoroughgoing mycological studies dealt with *Godronia cassandrae, Penicillium glaucum, Tryblidiella* spp., *Pilacre faginea,* and *Pezizella lythri,* with one excursion into the realm of medical mycology in a paper on a new ascomycete associated with granular mycetoma of man.

In 1923 Shear was made head of the newly established Division of Mycology and Disease Survey in the Bureau of Plant Industry, which was formed by consolidation of the former Divisions of Mycological and Pathological Collections and the Plant Disease Survey. He was now able to devote most of his time to his mycological interests with a minimum of distractions from the small fruit disease project or administrative duties which were mostly handed over to his project leaders.

In collaboration with B. O. Dodge there appeared in 1927 the history-making paper on *The life histories and heterothallism of the red bread-mold fungi of the Monilia sitophila group* which brought *Neurospora* into genetic fame and might be said to have been the publication that launched a thousand papers.

Dr. F. E. Clements had interested Shear in cooperating on a second enlarged edition of his Genera of Fungi which finally appeared in 1931 under their joint names. Shear was far from satisfied with the book, in the preparation of which he had had relatively little to do, and he immediately commenced gathering corrections and additions and planning on a revised edition to more nearly meet his own thinking in matters of fungus taxonomy and nomenclature. Circumstances prevented realization of this plan.

As a mycological hobby Shear was long interested in the Xylariaceae. He collected material at every opportunity, gathered specimens from correspondents, and examined material in other herbaria here and abroad. He assembled an amazing number of specimens, including types and other critically studied material, photographs, microscopic mounts, descriptions and other printed matter on the group together with the extensive notes resulting from his own studies. Several preliminary papers were published from time to time but press of other duties and finally ill health prevented the preparation of the monographic account which he planned and dreamed of.

In the course of his work with the pathogenic fungi of the cranberry and other small fruits he was led necessarily into a deep interest in the historical background of American mycology. Aided and abetted by

his long-time colleague, N. E. Stevens, he explored the collecting grounds of Schweinitz, Curtis, Ravenel and Michener and gathered copies of their letters and other information concerning them. Much of the material so gathered was published jointly. As part of these historical inquiries, the Michener collection was found in an attic in Pennsylvania, purchased personally and brought to Washington, where it now forms one of the prized possessions of the National Fungus Collections. Michener will be remembered as the mycologist who worked over the Schweinitz herbarium at Philadelphia with permission to divide each specimen as payment for his labor, thus, in effect, setting up a second Schweinitz herbarium.

Throughout his career Shear participated actively in a number of botanical and other technical organizations. As early as 1893 he was president of the Gray Memorial Chapter of the Agassiz Association, later the Gray Memorial Botanical Association, and active in its affairs for some years. Together with Peck, Thaxter, Earle and other notable charter members he was a moving spirit in the American Mycological Society during its brief existence, 1903–1906, acting as its secretary-treasurer at the time the Society merged with the Botanical Society of America. In later years he was a charter member and the second president of the Mycological Society of America. He was elected to the Botanical Society of America in its early days when membership was a privilege restricted to the "elect" and was its vice-president in 1908.

The story of his long and intimate associations with the American Phytopathological Society has been reviewed in Phytopathology. The Botanical Society of Washington claimed him as a charter member and he served as president in 1913. He was elected to Sigma Xi at Nebraska and later affiliated with the Washington Chapter, serving as president, 1918–20. He became a fellow of the American Association for the Advancement of Science in 1901 and was long interested in the History of Science Society. At various times he also held membership in the British Mycological Society, the Washington Biologists Field Club, and the American Society of Naturalists. Shear was a well-known figure at the annual meeting of the A.A.A.S. and affiliated societies. He thoroughly enjoyed these winter meetings and never missed one during his active career, if funds could be located by any means.

Shear's interests were not confined to the national scene. He was an American delegate to the second International Botanical Congress in Vienna in 1905. Although appointed a delegate to the third Congress at Brussels in 1910, he was unable to attend but took part in the nomen-

clatorial controversy which was raging at the time. Prior to the fourth Congress at Ithaca, New York, in 1926 he took an active part in the preliminary discussions led by A. S. Hitchcock looking to a reconciliation through compromises of the followers of the American Code and the International Rules of Botanical Nomenclature. He, of course, was present at the Ithaca Congress and was again an official delegate to the fifth Congress at Cambridge, England, in 1930, where he served as secretary of the fungus committee. He held this position until just prior to the seventh Congress at Stockholm in 1950, when he resigned due to ill health. A detailed account of Dr. Shear's activities in the field of botanical nomenclature will appear in TAXON.

Dr. Shear was an indefatigable collector of fungus specimens. Comment has already been made on his activities in this connection at Alcove, and the urge to gather in mycological material never left him, so that the fungus accumulations of a long life form an outstanding part of the National Fungus Collections. His collections were made at every opportunity, on mycological forays, official and self-conducted, on official trips as part of the phytopathological work, during attendance at national and international meetings, weather permitting, and in the earlier days from the Department of Agriculture and Arlington Experiment Station grounds. Any fungus which reared its head on the home grounds was certain to wind up in a shredded wheat box in room 313, West Wing, Agricultural Building in Washington. More than half of the states of this country and a dozen or more European countries from Italy to Scotland and Sweden contributed herbarium material.

During 1927–28 Shear and N. E. Stevens devoted six months to a thoroughgoing mycological exploration of the Hawaiian Islands. Petrak has published on some of these collections but many remain unworked.

All of Dr. Shear's fungus collections, his mycological correspondence with the great and the near great of the profession, his unpublished technical notes, his microscopic preparations, much of his library and other mycological materials have become a large and integral part of the National Fungus Collections at Beltsville and form a lasting memorial to his life and work.

Retirement came in 1935, but Shear continued his mycological pursuits without interruption. As a collaborator of the Department of Agriculture he retained his office with its enormous accumulation of specimens, records, reprints, correspondence and card files, all with a highly mycological flavor. Winters were spent in Florida for a number of years and the opportunity to collect fungi utilized to the utmost. Special attention was always given to the Xylariaceae, but other groups

were not neglected. Several preliminary papers on the genus *Hypoxylon* were published as well as a series of papers under the general title *Mycological Notes* in which he brought together his findings on the taxonomy and nomenclature of a wide range of fungi which he had had occasion to study during the active years spent in mycological pursuits.

Following his wife's death in 1950, he gave up the home in Arlington, Virginia, and went to live with his older daughter in Monroe, Louisiana. Here a heart condition confined him for the most part to bed, but he remained mentally alert until the last and continually interested in the affairs of the botanical world. His six children, Sherwood F., of Berkeley, California; Deming F., of Falls Church, Virginia; Mrs. Beatrice Cretney, Monroe, Louisiana; G. Myron, Blacksburg, Virginia; Mrs. Dorothy Miles, Vienna, Virginia, and Cornelius B., Gainesville, Florida, survived him, together with many grandchildren and great-grandchildren.

Dr. Shear will long be remembered as a modest, retiring, but effective worker, who, though shy and bashful as a youth, if we accept his own statement, through quiet perseverance and native ability rose to prominence in his beloved profession, despite difficulties that would have deterred many another would-be botanist. Through his numerous contributions expressed as technical papers, as service to technical societies and as wise counsel to numerous associates and other professional colleagues he has gained an assured place in the history of botanical science.

The photograph reproduced here was taken during the summer meeting of the Mycological Society of America at Gatlinburg, Tennessee, August 1939. Beside Dr. Shear, then the Dean of American mycologists, stands Dr. John Dearness, the Dean of Canadian mycologists. A more formal portrait was published in volume 26 of MYCOLOGIA, in connection with his presidential address.

HORTICULTURAL CROPS RESEARCH BRANCH,
AGRICULTURAL RESEARCH SERVICE,
UNITED STATES DEPARTMENT OF AGRICULTURE,
BELTSVILLE, MARYLAND

THE WRITINGS OF C. L. SHEAR[1]

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NOTES AND BRIEF ARTICLES

A NEW SPECIES OF PHYSODERMA ON DULICHIUM [1]

In the course of studies of the phycomycetous flora in the region of the University of Michigan Biological Station at Douglas Lake during the Summer of 1956 an interesting chytridiaceous organism was found parasitic on the aquatic sedge, *Dulichium arundinaceum* (L.) Britt. The parasite was readily identified as a member of the genus *Physoderma.* Several characteristics distinguish it from other members of the genus and justify its description as a new species.

Physoderma dulichii sp. nov.

Sporangia epibiotica ephemeralia primum sphaerica deinde obovoidea vel obpyriformia 18.8–29.9 × 36.1–48.7 μ. Systema endobioticum in cellulas epidermales hospitis folii nondum maturatas penetrans et intus fasciculum multiramosum rhizoideorum tenuium 12.4–18.6 μ ambitu formans; sub loco penetrato hospes cicatricem persistentem orbiculatam 3.4–5.5 μ diametro formans. Zoosporae sphaericae 4.8–5.5 μ diametro vel magis ovoideae 3.4–4.1 × 7.6–8.3 μ, flagello postico 27.5–31.7 μ longitudine et globulo prominente eccentrico 2–2.8 μ diametiente, ex sporangio ultime per papillam apicalem latam 9.6–11 μ diametro deliquiscentem emergentes. Rhizomycelium endobioticum tenue, subtile, ramosum, tantummodo in epiderme superiore folii intra cellulas plures ramificiens, granula refractiva conspicua continens, multas sporas perdurantes inchoatas sphaericas atque aseptatas gignens, etiam cellulas turbinatas uniseptatas vel biseptatas 6.2–9.6 × 8.2–12.4 μ. Sporae perdurantes aut de cellulis turbinatis aut de rudimentis aseptatis fictae in cellulis epidermalibus hospitis solitariae vel usque quarternae repertae; membrana sucinea crassa et guttulis ordinatis circumtectae, intus vacuolo magno; sphaericae vel ovoideae 14.1–39.2 × 25.1–59.7 μ vel aliquantulo deformatae ob compressionem inter se sub pelle hospitis cellulae concludiente; fascicula ramulorum bisulcorum 7.85–11 μ longitudine aut singula aut plura simul efferentes. Germinatio nondum observata.

Ephemeral epibiotic sporangia at first spherical, subsequently obovoid to obpyriform, 18.8–29.9 × 36.1–48.7 μ; endobiotic system penetrating immature upper epidermal leaf cells of the host to form a bushy tuft of delicate rhizoids 12.4–18.6 μ in extent, stimulating formation by the host of a persistent ring of callus 3.4–5.5 μ in diameter internally at the point of penetration of the host cell wall; zoospores spherical, 4.8–5.5 μ in diameter, to somewhat ovoid, 3.4–4.1 × 7.6–8.3 μ, with a posteriorly directed flagellum 27.5–31.7 μ in length, and a prominent eccentric

[1] Contribution No. 1067 from the Department of Botany, University of Michigan.

oil globule 2–2.8 μ in diameter; at maturity discharged from the sporangium upon deliquescence of a broad apical papilla 9.6–11 μ in diameter. Endobiotic rhizomycelium tenuous, delicate, branched, limited to the upper epidermis of the leaf and ramifying through several cells; containing conspicuous refractive granules and producing numerous spherical non-septate resting spore rudiments and 1- and 2-septate turbinate cells, 6.2–9.6 × 8.2–12.4 μ. Resting spores formed either from turbinate cells or non-septate rudiments; one to four in each host epidermal cell; with thick amber walls, uniformly placed peripheral guttulae, and a large central vacuole; spherical to ovoid or somewhat irregular in shape, 14.1–39.2 × 25.1–59.7 μ due to mutual compression and confinement by the host cell wall; bearing one to several clusters of dichotomously branched appendages 7.8–11.0 μ in length; germination not observed.

Parasitic in the upper epidermis of leaves of *Dulichium arundinaceum* where it causes irregular areas of brownish discoloration. Smith's Bog, Cheboygan County, Michigan, 30 June, 1956, et seq.

This appears to be the only described species of *Physoderma* which is limited to the epidermis of its host. Two other species of the genus have been described as parasites of the Cyperaceae. *Physoderma schroeteri* is found on *Scirpus maritimus, S. supinus,* and *Eleocharis palustris; Physoderma heleocharidis* is parasitic on *Eleocharis palustris. Physoderma dulichii* is strikingly different from these species in resting spore size and morphology as well as in symptomology.

In addition to the type locality, *P. dulichii* is known from several other Michigan sites, from Ontario, Indiana, Pennsylvania and Maine. Its biology is under intensive study and will be reported more completely in the near future.—ROBERT M. JOHNS, Department of Botany, University of Michigan, Ann Arbor, Michigan.

A NOTE ON THE CHANGES IN COLOR IN THE ASPERGILLUS NIGER GROUP DUE TO THE PROXIMITY OF A DEGENERATE MUCOR

During the isolation of molds in connection with work on the molding of books (in 1947) a pale brown *Aspergillus* was encountered which on examination proved to belong to the *niger* group. This form, when sub-cultured, gave a colony of the normal deep chocolate-brown color. It was noted on the original plate the *Aspergillus niger* was in close proximity with a yeast-like colony. Prof. Barker has kindly identified this organism as a degenerate *Mucor.* It is a well-known fact that *Mucor* spp.. form sprout mycelia, and the writer has since

observed that some will do so readily on agar which contains about 0.1% of phenol.

Pure cultures of both the *Aspergillus* and the *Mucor* were made and further plates inoculated with both. In most cases pale brown to dirty cream colonies of *Aspergillus* were obtained, though in a few instances small portions of the colonies would be of approximately the normal color. Further experiments showed that two other standard cultures of *Aspergillus niger* also underwent the same changes when grown together with the *Mucor*. A purple member of the group was then tried, namely *A. japonicus* Saito, and this gave rise to a whitish-gray colony. This change in color has not been noticed in *Aspergilli* growing next to normal *Mucors,* and it is apparent that the degenerate form is capable of producing different substances in the medium from those produced by the normal forms.

A microscopical examination of the spores in *A. japonicus* shows that those of the pale "ecovar" are much less spiny than those from a typical culture.—BERNARD VERDCOURT, East African Herbarium, Nairobi, Kenya.

MARINE MYCOLOGY

A course in Marine Mycology, carrying 6 semester hours of graduate or senior credit, will be offered from June 11 through July 17, 1957, at the Duke Marine Laboratory, Beaufort, North Carolina. The study of marine and brackish-water fungi is approached through a minimum of lectures, and a maximum number of hours of supervised laboratory study, field work, assigned readings, and independent investigation. Methods of trapping, isolation, and culturing, together with taxonomic and basic physiological studies, constitute one-third of the course; research on special projects selected by the participants constitutes the remainder. Students will have opportunity to become acquainted with other fields of marine biology such as oceanography, bacteriology, invertebrate zoology, and phycology, through the medium of the course, and by participation in station seminars.

Fee, including tuition, and room and board, total $197.50. A limited program of financial assistance will likely be available. For further details regarding the facilities and fees at the Laboratory, and for application forms, write Professor C. G. Bookhout, Director, Duke University Marine Laboratory, Department of Zoology, Duke University, Durham, North Carolina.—T. W. JOHNSON, JR.

REVIEWS

DISEASES OF FIELD CROPS, by James G. Dickson. 2 ed. xi + 517 pp., 102 figs. McGraw-Hill Book Co., New York. 1956. Price, $8.50.

The first edition of this book, published in 1947, became at once a popular text and a valued reference source in its field. The new edition has been revised carefully to incorporate new information which has accumulated during the past decade, and substantially enlarged. While the total number of illustrations remains the same as in the earlier edition, some of them are new and others appear to have been reengraved. Those that have apparently been printed from the old cuts are greatly improved in appearance because of the much better quality of the paper used.

The arrangement is essentially the same as that of the first edition. The two introductory chapters are followed by sections on diseases of cereals and grasses, diseases of legumes (with two new chapters), and diseases of fiber and other field crops. An appendix on diseases of field crops arranged by causal factor and another on bacteria and fungi arranged under orders and families, the latter carefully indexed to the body of the text, serve to unify the scattered treatment necessitated by the host sequence. There is, in addition, a complete general index.

The increased attention to virus diseases reflects the very great recent advance in our knowledge in this field. While virus diseases were, of course, recognized in the earlier volume, they are given much more space in the revision and some diseases formerly referred to the "non-parasitic" category are now recognized as due to viruses.

From a mycological standpoint it is encouraging to see a text of this nature in which an honest effort is made to follow, with proper conservatism, the changing situation in fungous classification. Some of the more obvious faults in the older systems are corrected and the imperfect names for pleomorphic fungi are used wherever it seems desirable. There is frank recognition that changes are inevitable and are an expression of growing, if still highly inadequate, concepts of relationships within the fungi.

Practically every page shows evidence of careful revision. Typographical errors have been kept to a minimum. There is every reason to suppose that this book will be as successful as its predecessor.—G. W. MARTIN.

MANUAL DE MICOLOGIA MÉDICA, by Carlos da Silva Lapaz. Ed. 2. x + 422 pp., 2 pl. (1 col.) + 161 f. Irmaos Dupont, São Paulo, Brazil. 1956. Price not given.

To those acquainted with the flourishing status of medical mycology throughout Latin America, it comes as no surprise that a second and revised edition of Carlos da Silva Lacaz's Manual de Micologia Médica has been published three years after the appearance of the first one.

Basically few changes have been made in the 1956 edition. New sections on the treatment of mycotic infections and medications have been added along with a greater number of photographs and drawings.

The author has adhered to convention in the treatment of the subject matter. The first four chapters are devoted to the taxonomy of fungi in general; their morphology and biological properties, a general description of mycotic diseases and methods for the isolation and cultivation of human pathogenic fungi. Two long chapters cover the dermatomycoses and the subcutaneous and systemic fungus diseases of man. These are followed by a synopsis of the mycoses categorizing them according to the organs and tissues of the body that they invade. Allergies due to fungi are discussed in a chapter along with the presentation of line drawings of representative fungi of the Fungi Imperfecti, Ascomycetes and Phycomycetes. The last two chapters list formulae for medications and procedures for studying the mycoses and their agents histologically and immunologically. A group of selected references is appended as well as an index.

The greatest value of this book lies in its description of the clinical aspects of the mycoses but the diagnostic features of the human pathogenic fungi are inadequately presented. Both physicians and laboratory workers would profit if more space were devoted to full descriptions of the etiologic agents of the mycoses.

The book is well printed and is amply illustrated. It should prove to be of value to all interested in medical mycology.—LIBERO AJELLO.

INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE ADOPTED BY THE EIGHTH INTERNATIONAL BOTANICAL CONGRESS, PARIS, JULY 1954. 338 pp. International Bureau for Plant Taxonomy and Nomenclature, Utrecht, 1956. Price, free to Institute members of the International Association for Plant Taxonomy; to personal members, $3.50; to others, $7.00.

The currently effective version of the International Rules, the work of the Section on Nomenclature of the Paris Congress and an editorial committee of ten, is now available for study and application. Substantial changes from the superseded Stockholm Code are relatively few and relatively slight—surely a matter for thanksgiving. The arrangement of the various provisions of the Code has been thoroughly worked over, in a logical and comprehensible fashion; even those familiar enough with past editions to need to unlearn the old systems of numbering will find it easier to find a desired rule in the present one. Where logic is not enough, a parallel table of new and old numbers for the Rules and Recommendations is provided. Those who never refer to an organism by its scientific name, and never attempt to interpret a scientific name used by anyone else, may disregard this work. All others should not only have the new Code available for reference, but should read it through, thoughtfully, at least once.—DONALD P. ROGERS.

BIBLIOGRAPHIE DER PFLANZENSCHUTZ-LITERATUR, 1950, by J. Barner. xli + 438 pp. Biologische Bundesanstalt für Land- und Forstwirtschaft in Berlin-Dahlem. Verlag Paul Parey, Berlin, 1956. Price, DM 42 (about $10.50).

The present volume is the first of the promised volumes designed to fill the gap between 1946 and 1950 that were omitted from earlier printings (MYCOLOGIA **48**: 615. 1956). Further volumes covering these omitted years are in preparation.—J. C. GILMAN.

MANUSCRIPT

Publication in MYCOLOGIA is ordinarily restricted to those who have been members in good standing of the Mycological Society of America for over a year immediately preceding submission of manuscript. Exceptions to this regulation require a favorable vote by a majority of the Editorial Board. When a paper has two or more authors, the person submitting the paper is expected to be a member.

Papers should be submitted in duplicate, typewritten and *double-spaced throughout,* to any member of the Editorial Board. When papers are not submitted in proper form, it may be necessary to return them to authors. They will be published in approximate order of their acceptance, except for the address of the retiring President and papers whose cost of publication is paid by the authors, the latter run as excess pagination.

All illustrations should be numbered consecutively throughout a paper, using arabic numbers and small letters for subdivisions, e.g., Fig. 1, a etc. This does not mean that all figures grouped for convenience on a single page need have a single number. Figures should be prepared so that, when reduced, the width will not exceed 4 inches, and should be short enough to permit the insertion of the legend beneath the figures. Each article will be restricted to twenty pages, including illustrations, except when authors submit only one paper in two or three years of membership, in which case the restriction will be thirty and forty pages respectively. Ruled tabular matter is counted double. Should an author wish to publish additional pages in one article he may do so by paying for the excess pages at current rates.

Citations of literature should be *double-spaced,* arranged in alphabetical order and cited by numbers or dates. In citing papers with two or more authors, only the first author should have the initials after the surname. The address of the author should appear at the end of the text, before the bibliography.

Each author will be restricted to two pages of half-tone illustrations or three of zinc line-engravings for each article, the total cost not to exceed $25. If figures are mounted on board, the cost of routing may be such as to restrict the space allowance substantially. Should the cost of cuts exceed $25, the author will be asked to pay the excess.

To comply with the International Rules, it is recommended that contributors furnish *brief* Latin diagnoses of all new species and genera when their manuscript is submitted for publication.

Partial List of Publications of The New York Botanical Garden

Mycologia, bimonthly; devoted to fungi, including lichens; containing technical articles and news and notes of general interest. $8.50 a year; single copies $1.75 each.

Established by The New York Botanical Garden in 1909, in continuation of the Journal of Mycology, founded by W. A. Kellerman, J. B. Ellis, and B. M. Everhart in 1885. Edited by William Alphonso Murrill, 1909–1924. Edited by Fred Jay Seaver, 1924–1946; by Alexander H. Smith, 1946–1950. Beginning with January, 1933, the official organ of the Mycological Society of America.

North American Flora. Descriptions of the wild plants of North America, including Greenland, the West Indies, and Central America. Planned to be completed in 34 volumes. Roy. 8vo. Each volume to consist of four or more parts. [Not offered in exchange.] Volumes 1–10 devoted to fungi.

Vol. 1, part 1, 1949. Myxomycetes. $7.25.

Vol. 2, part 1, 1937. Blastocladiaceae, Monoblepharidaceae, Saprolegniaceae, Ectrogellaceae, Leptomitaceae. $2.00.

Vol. 3, part 1, 1910. Nectriaceae-Fimetariaceae. $2.00. (Out of print.)

Vol. 6, part 1, 1922. Phyllostictaceae (pars). $2.00.

Vol. 7 (now complete), parts 1–15, 1906–1940. Ustilaginaceae-Aecidiaceae. $2.00 per part. (Parts 1–5 out of print.)

Vol. 9 (now complete), parts 1–7, 1907–1916. Polyporaceae-Agaricaceae (pars). $2.00 per part. (Parts 1–3 out of print.)

Vol. 10, part 1, 1914; parts 2 and 3, 1917; part 4, 1924; part 5, 1932. Agaricaceae (pars). $2.00 per part.

Series II, part 1, 1954. Tuberales. $1.60.

The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. By Henry A. Gleason. 3 volumes. List price $30.00 per set; shipping charge $0.50. Succeeds the Illustrated Flora by Nathaniel L. Britton and Addison Brown. Includes descriptions and drawings of the plant species, from ferns to orchids, which grow without cultivation in the area extending from the St. Lawrence River to Virginia and westward to Missouri and Minnesota.

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